I.T.E.C.

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50
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THE HOME STUDY COURSE IN ELECTRONICS AND COMPUTERS

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Cover: NASA astronaut harnessed into a manned manoeuvring unit. Each MMU is loaded with 26 lbs of nitrogen propellant in two aluminium tanks. 1.7 lbs of thrust is provided by 24 jets.

INDEX

To enable you to get the most out of I.T.E.C., a fully cross-referenced Index to the complete five-volume work is available in Part 51.

(continued from part 49)

OCCAM

OCCAM is the programming language that has been specially developed for the transputer. As we have said, transputers can be programmed in most standard high level languages, but OCCAM best exploits the transputer's special features.

The main feature of the language is its treatment of concurrency. OCCAM enables programmers to utilise concurrency by encapsulating the actions of input, output and interrupts in a simple form. The architecture of the transputer is optimised to run OCCAM programs, and the language is so efficient that the need for an assembler is eliminated. Prior to the development of OCCAM, there was no simple way of prgramming parallel systems – this absence of a programming technique held back the development of advanced architectures like the transputer.

The new language was developed by David May (INMOS) and Professor C A Hoare (Oxford University). They took its name from the 14th century philosopher William of Occam, known for his principle '*Entia non sunt multiplicanda praeter necessitatem*', which translates into 'entities should not be multiplied beyond necessity', or 'keep it simple'. This is perhaps better known as **Occam's Razor**.

OCCAM has only 22 reserved words and combines contemporary thought on structures with radical approaches to new structures to handle parallel processing. It is based on a computational model that differs from conventional languages as it includes the notions of communication, parallel execution and synchronisation in its structure. Inputs, outputs and interrupts are handled at a high level that is 'invisible' to the programmer.

The language has been designed for system programming and can only carry out integer (whole number) arithmetic. As yet it has no built-in support for graphics or file and string handling, however the incorporation of floating point and multiple precision arithmetic is planned.

OCCAM's basic building block is a **process**, which performs a sequence of operations and then stops. Although these processes are similar to those in other programming languages (BBC BASIC, for instance), the difference is that more than one process can be in operation *at the same time*.

Programs are built from three **primitive processes**: input, output and assignment. All other processes, i.e. sequential, parallel or alternative constructions, are made from combinations of these primitives. We'll look at the action of the primitive processes first.

The input and output processes transfer a word (of 32 bits in the case of the IMS T424 transputer) from a **channel** to or from a variable:

```
brick! x
```

for instance, outputs the value of the variable x to the channel called 'brick';

```
brick? y
```

on the other hand, reads the value from channel 'brick' into the variable y.

Channels (like variables) have to be **declared** at the beginning of the process in which they are used. They can be implemented as serial communications links between transputers, or between memory locations that exchange data inside the same transputer – it doesn't matter to the program. Channels have a *one way* flow of information – you cannot input and output from one channel in the same process.

The **assignment process** changes the value of a variable in the same way as BASIC:

```
a: = b + 10
```

for example.

The simplest **compound process** is the **sequential construct** (SEQ):

```
VAR a:
SEQ
keyboard? a
screen ! a
```

This executes the processes of input and output (taking the variable, a, from the keyboard and sending it to the screen display) one after the other as in any ordinary programming language.

A sequential construct terminates only after the last of its component processes has finished. Processes can be given names (like procedures) so that they can be recalled, as in other languages, for example:

```
PROC echo (CHAN in, out) =
  WHILE TRUE
    VAR x:
    SEQ
      in? x
      out! x
```

defines the process, and simply by writing 'PROC echo (CHAN in, out)' in other parts of the program, the whole process can be called up again.

The two other compound processes are PAR (parallel) and ALT (alternative). The PAR instruction shows that the sub-processes that follow it (when written) will be executed concurrently. If these processes need to communicate with each other over a channel, then the first process to be ready waits for the other. This is all handled by OCCAM's automatic synchronisation. As an example of a **parallel construct**, consider:

```
PAR
  out 1! 'a'
  out 2! 'b'
```

which executes two outputs at once and each instruction waits until the other's output is ready.

The **alternative construct** provides the programmer with a method of choosing between two processes in time. It will 'watch' a group of input channels and execute the process that belongs to the input that comes first:

```
ALT
  in 1? char
    out! char
  in 2? char
    out! char
```

The ALT process ends when the chosen process finishes execution.

A more usual method of selection is carried out with the **conditional constructor**, IF. Each process has a conditional component, with resulting action to be taken if the condition is true:

```
IF
  x < 0
    x: = -x
  x > = 0
    SKIP
```

8

Instruction format

7	6	5	4	3	2	1	0
Function				Data			

One address instructions

Load local	Load constant
Store local	Add constant
Load local pointer	Add to memory
Load non-local	Jump
Store non-local	Conditional jump
Load non-local	Call
pointer	Adjust workspace

Zero address instructions

Add	Load byte
Subtract	Store byte
Multiply	Byte count
Divide	Word count
Remainder	Byte subscript
Long add	Word subscript
Long subtract	Check subscript
Long multiply	Extend to word
Long divide	Check partword
Normalise	Extend to double
	Check word
Difference	Read timer
Greater than	Test error
Equal zero	Reverse
	Return
And	Minimum integer
Or	Initialise
Xor	
	Start process
Shift left	End process
Shift right	Alt start
	Enable channel
Move message	Enable timer
Input message	Disable channel
Output message	Disable timer
	Alt wait

8. The complete instruction set and instruction format for the IMS T424 transputer.

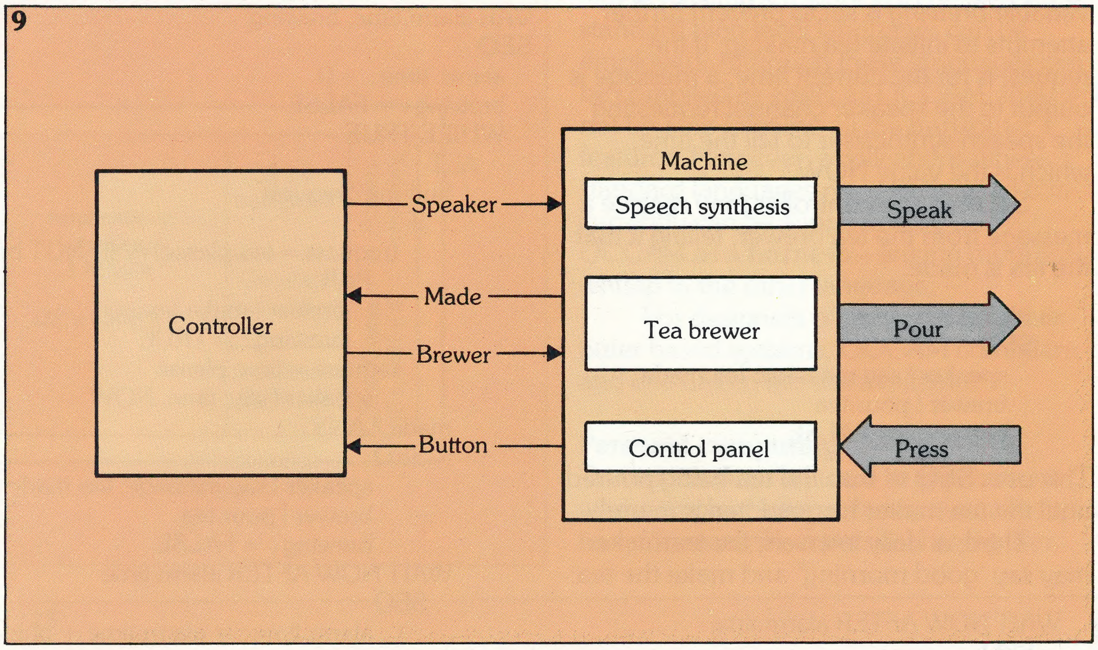
The construct that is chosen ends when the chosen process terminates.

As in other languages, loops can be implemented with a WHILE <Condition> for example:

```
WHILE x > 0
  SEQ
    in? x
    out! x
```

This will be repeatedly executed until the condition is false.

The transputer also supports a time function, to cater for real time programming. The timing function is derived from each transputer's clock and is accessed via the channel TIME, and may be used to control the execution of a process. The instruction:



9. System diagram for the tea-maker.

TIME? AFTER t
will hold the execution of a process, until the amount of time specified by t has elapsed.

The transputer's complete instruction set and the corresponding instruction format are shown in *figure 8*. There are two classes of instruction: **one address instructions** and **zero address instructions**. In one address instructions, the operand is used by the function as a value, while in zero address instructions the operand is used to define an operation on the values in the evaluation stack (i.e. the stack of registers where the data to be operated on is held).

An example OCCAM program

In its handbook on the OCCAM language, INMOS gives an example of a simple program which controls the operation of a tea-making machine. The machine wakes you up in the morning with a spoken message and pours a cup of tea; it is also a clock and will make tea at any other time on request.

The tea-maker's system diagram, represented as a network, is shown in *figure 9*. Each unit is described as a process, and each connection is made by a channel. A process can be constructed from smaller processes, indeed the collection of processes is itself a process and could be part of a larger system.

This network is represented by defining the channels and processes. The statement CHAN introduces the channels through which the processes communicate, and the PAR construct causes the various processes to operate concurrently:

```
CHAN speaker, made, brewer, button:
PAR -- tea.maker
  ...   --controller
  PAR --machine
    ...   --speech.synthesis
    ...   --tea.brewer
    ...   --control.panel
```

The controller may do one of three things. First, it may receive a message from the request buttons asking it to make tea, or tell the time:

```
button ? request
  IF
    (request = tea.please) AND NOT brewing
      PAR
        brewer ! make.tea
        brewing : = TRUE
    request = time.please
      speaker ! say.time; NOW
```

This inputs a request from the button channel, and uses IF to determine whether it is a request for tea, or a request for the time. If it is a request for tea, a message is output to the brewer channel telling the tea brewer to make the tea, and the boolean

variable *brewing* is set to prevent further attempts to initiate tea making. If the request is for the current time, a message is output to the speaker channel requesting the speech synthesiser to tell the time, which is the value NOW.

Second, the controller may receive a message from the tea brewer, telling it that the tea is made:

```
made ? ANY
  SEQ
    speaker ! say.message; tea.made
    brewer ! pour.tea
    brewing : = FALSE
```

This uses SEQ to stop the tea being poured until the tea maker has said 'tea is made'.

Third, at daily intervals, the tea-maker may say 'good morning' and make the tea:

```
WAIT NOW AFTER alarm.time
  SEQ
    alarm.time : = alarm.time + one.day
    speaker ! say.message; good.morning
    IF
      NOT brewing
        PAR
          brewer ! make.tea
          brewing : = TRUE
```

These individual program sections, each of which is a process, are combined into the complete controller process by declaring the local variables, and by using WHILE and ALT to enable the controller to perform whichever alternative is required.

```
VAR alarm.time, brewing:
SEQ
  alarm. time : = 0
  brewing : = FALSE
  WHILE TRUE
    ALT
      buttons ? request
        IF
          (request = tea.please) AND NOT brewing
            PAR
              brewer ! make.tea
              brewing : = TRUE
          request = time.please
            speaker ! say. time; NOW
      made ? ANY
        SEQ
          speaker ! say.message; tea.made
          brewer ! pour.tea
          brewing : = FALSE
      WAIT NOW AFTER alarm.time
        SEQ
          alarm.time : = alarm.time + one.day
          speaker ! say.message; good.morning
          IF
            NOT brewing
              PAR
                brewer ! make.tea
                brewing : = TRUE
```

Development facilities

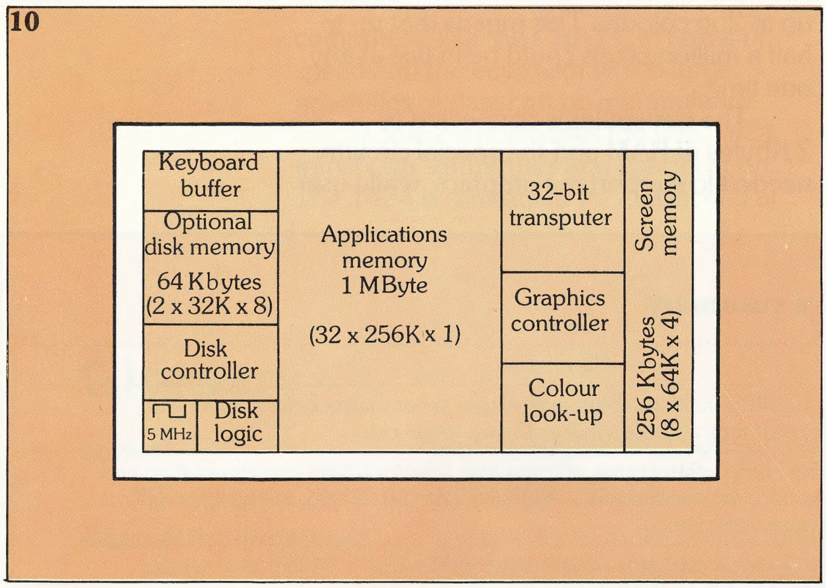
The transputer (as we have seen) has been designed to simplify the task of programming and developing applications, and the most efficient way to program it is to use OCCAM.

For other applications – especially

10. Layout of a personal computer PCB which incorporates an IMS T424 transputer, an INMOS G213 graphics controller and an M212 disk controller.

Left: this CAD terminal utilises a light pen and a separate keyboard (shown on the right) which calls up design functions. (Photo: IBM).

10



where existing software is to be re-used – standard high level languages can be employed. Although these languages can be compiled as easily as OCCAM, they will not be able to utilise all the transputer's features. However, applications where standard languages need to be used concurrently can be supported by using OCCAM as a **harness** – linking modules written in the other language.

For designers planning to use transputer based systems, OCCAM compilers and evaluation kits are available.

Personal computing

Transputers can be used in applications where single microprocessors usually function, for example, a personal computer.

11. Transputers arranged in: (a) a pipeline; and **(b)** an array.

11

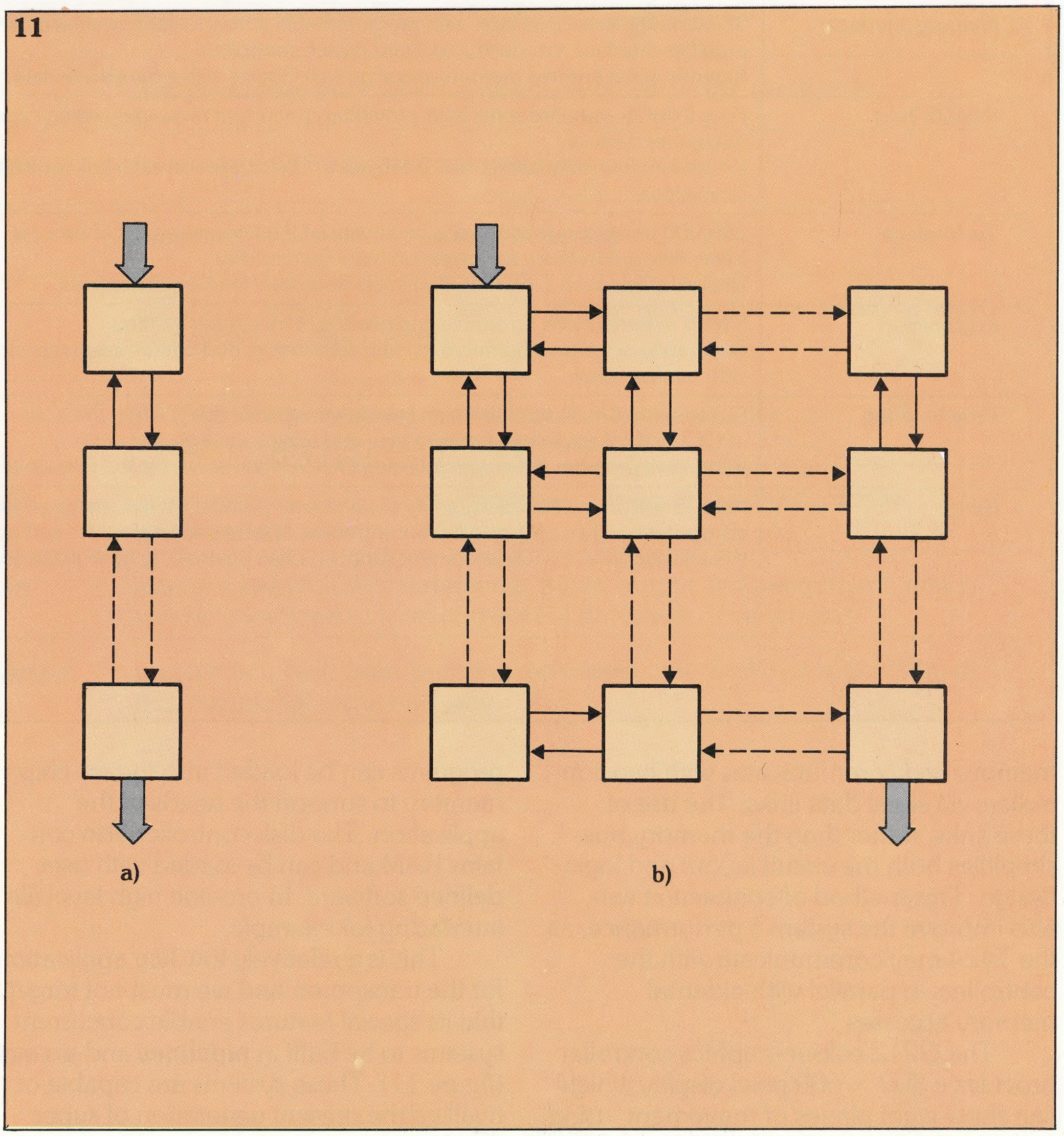


Figure 10 illustrates a personal computer PCB that uses an IMS T424 transputer, together with an INMOS G213 graphics controller and an M212 disk controller.

The IMS T424 can access 1 Mbyte of up to 256 colours. This means that up to half a million pixels could be in use at any one time.

The transputer is connected to 2 Kbytes of RAM and the special circuitry needed to support the graphics, while user

Table 2
The INMOS IMS T424 transputer – a summary

Feature	Comments
IMS T424	32-bit system providing 10 MIPS (millions of instructions per second) processing power with memory and concurrent communication capability, all on a single chip
Processor	Reduced instruction set for compact programs, efficient high level language implementation and direct support of concurrency. High performance arithmetic with 50 ns basic instructions, 600 ns process switch and 950 ns multiplication
Memory	4 Kbytes of static memory giving a maximum data rate of 80 Mbytes s^{-1}. Multiport access for processor, memory interface and each INMOS link
Memory interface	32-bit multiplexed interface, with programmable timing to support mixed memory systems. Also provides interface to industry standard device controllers Extends direct address memory space up to 4 Gbytes with a maximum data rate of 25 Mbytes s^{-1}
INMOS links	Four INMOS standard serial links providing concurrent message passing capability to other transputer devices Programmable data rate up to 1.5 Mbytes s^{-1} full duplex on each link to enable local and remote connection
Technology	250,000 transistors fabricated in an advanced 2 micrometre CMOS process Laser fuse redundancy for improved manufacturability Dissipates less than 1 W, mounted in an 84 contact leadless chip carrier
Engineering	5 MHz external clock for simple engineering of transputer systems Separately optimised interfaces to external memory and other transputers ensure high performance with minimal glue
Programming	Compilers for most standard high level languages: C, FORTRAN, PASCAL, ADA etc. Direct support of OCCAM for maximum performance and exploitation of concurrency Interactive program development using OCCAM as the lowest level image of the system
Range	INMOS will offer a complete family of transputer products. Initial members include a 16-bit transputer and two programmable controllers, one for colour graphics and one for floppy and Winchester disks. Full development support is also planned, to be in place alongside the first silicon

memory and communicates with two controllers via serial data links. The use of these links, rather than the memory bus, simplifies both the circuit layout and logic design. This method of connection can also improve the system's performance, as the T424 may communicate with the controllers in parallel with external memory accesses.

The G212 colour graphics controller provides a 800 × 600 pixel display which can show eight planes of movement, using programs can be loaded into the on-chip memory to support the needs of the application. The disk controller also contains RAM and can be loaded with user defined software, to provide high level file interfacing for example.

This is a relatively low key application for the transputer, and we must not forget that its special features enable concurrent systems to be built in **pipelines** and **arrays** (*figure 11*). These systems are capable of rivalling the present generation of super

computers, like the CRAYs, in terms of speed and the ease with which large quantities of data can be manipulated.

Table 2 summarises the IMS T424 transputer's attributes and specification. The T424 is scheduled for availability at the end of 1984, with other transputers to follow.

We would like to acknowledge the help given by INMOS in the preparation of this article.

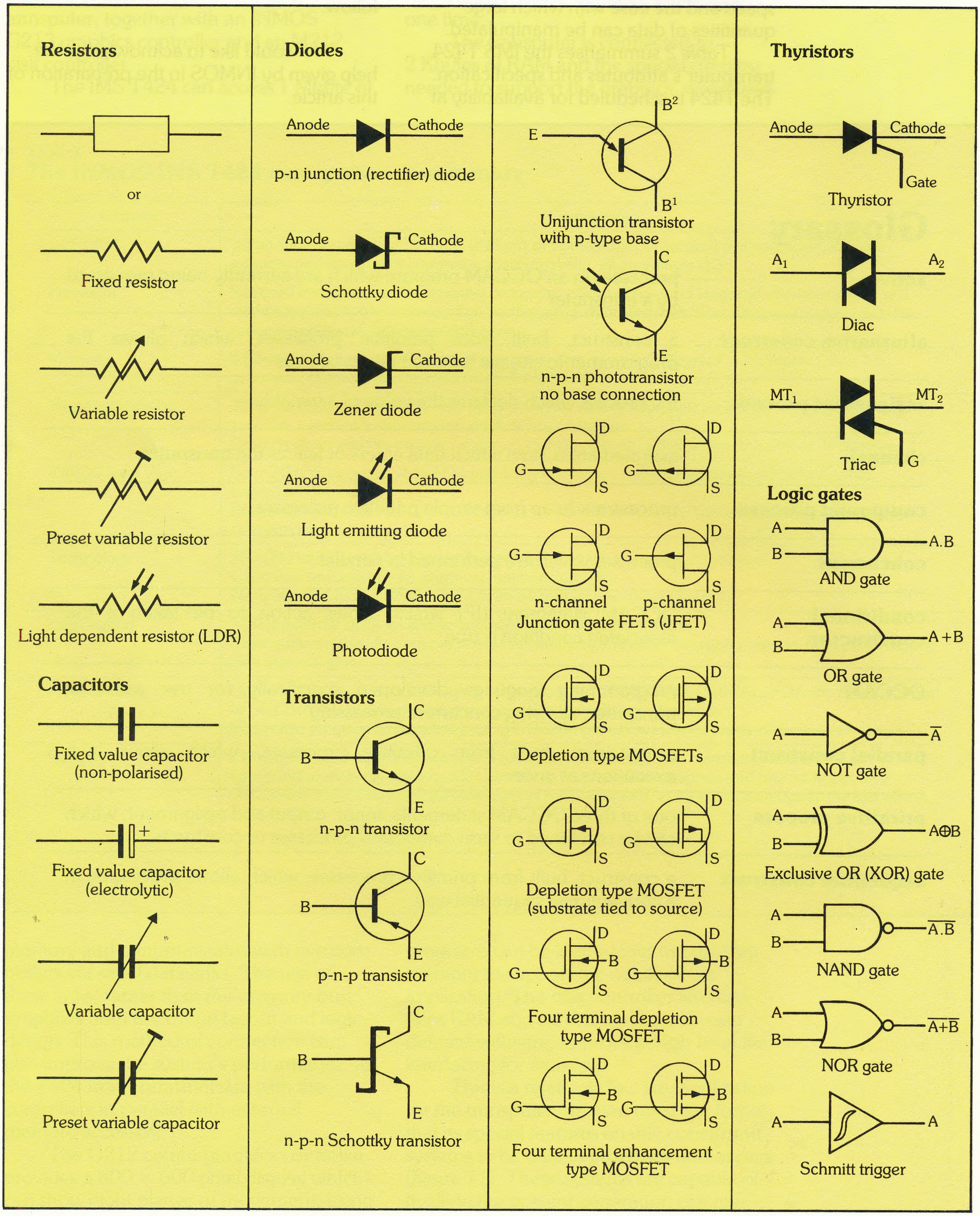
Glossary

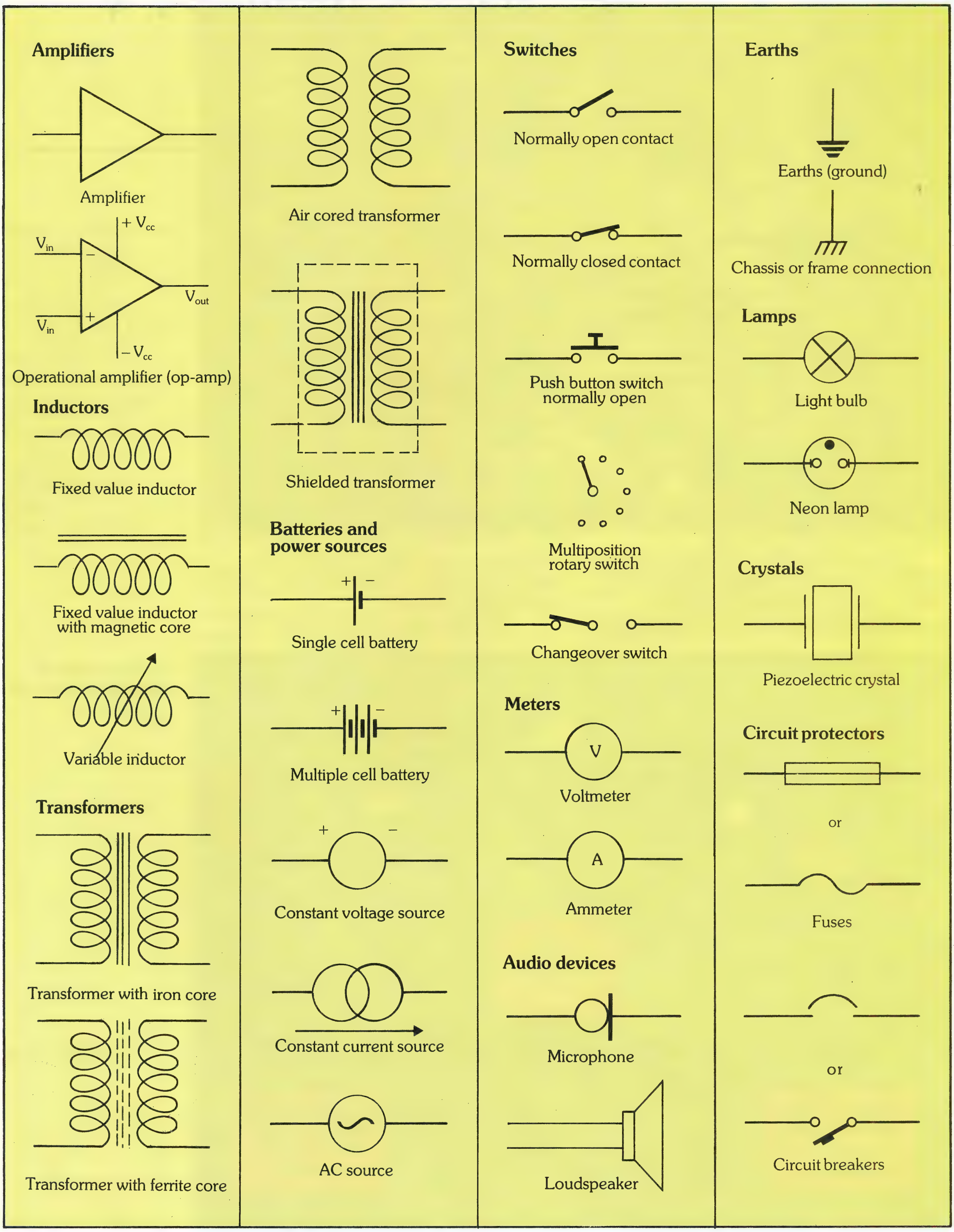
active	processes in an OCCAM program which are currently being processed by a transputer
alternative construct	a construct, built from primitive processes, which allows the programmer to choose between two processes
assignment process	the process which declares the value of a variable
channel	assigned areas from which data enters or leaves the transputer
compound process	process made up from simple primitive processes
concurrent	processes which are performed in parallel
conditional constructor	OCCAM statement (IF) which allows action to be taken if the associated condition is true
OCCAM	programming language developed specifically for use with the transputer, allowing concurrent processing
parallel construct	a construct, built from primitive processes, which allows two executions at once
primitive process	one of three OCCAM statements, input, output and assignment, which can be combined to form compound processes or constructs
sequential construct	a construct, built from primitive processes, which allows processing in a conventional sequential way

BASIC THEORY REFRESHER

ELECTRICAL TECHNOLOGY

Symbol summary




Amplifiers
Amplifier
+ Vcc
Vin
Vout
Vin
– Vcc
Operational amplifier (op-amp)
Inductors
Fixed value inductor
Fixed value inductor with magnetic core
Variable inductor
Transformers
Transformer with iron core
Transformer with ferrite core
Air cored transformer
Shielded transformer
Batteries and power sources
Single cell battery
Multiple cell battery
Constant voltage source
Constant current source
AC source
Switches
Normally open contact
Normally closed contact
Push button switch normally open
Multiposition rotary switch
Changeover switch
Meters
V
Voltmeter
A
Ammeter
Audio devices
Microphone
Loudspeaker
Earths
Earths (ground)
Chassis or frame connection
Lamps
Light bulb
Neon lamp
Crystals
Piezoelectric crystal
Circuit protectors
or
Fuses
or
Circuit breakers

22 COMMUNICATIONS

Cable and satellite TV

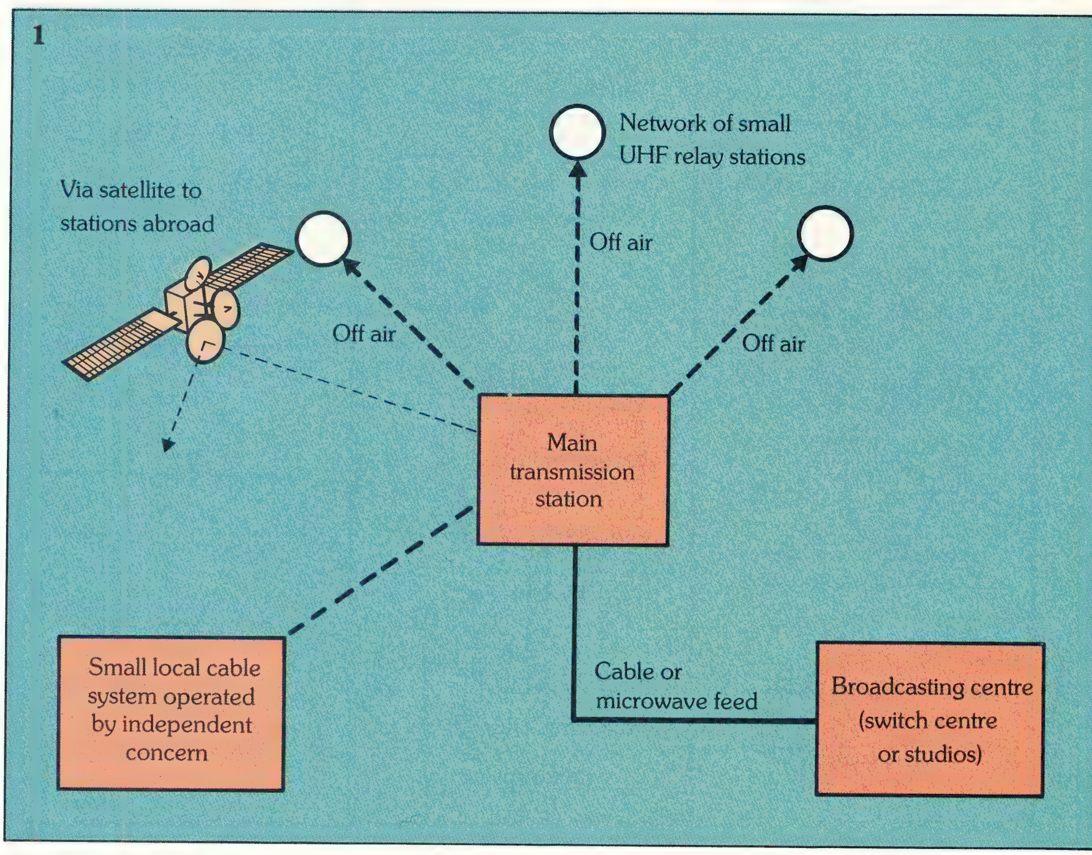
The development of cable TV

Until recently, the television receiver was the most complex piece of electrical hardware in the home. But in the last three years it has been technically outstripped by the video recorder and microcomputer. Now video and computer technologies are dragging television forward with them, providing the capacity to change the services it offers. The various methods of distributing television signals in the existing network are shown in *figure 1*.

Using cable and satellite services to distribute television signals directly to the home offers an enormous increase in choice: specialist channels, for example 24 hour films; community television; more teletext and telesoftware, and two-way (interactive) viewdata-type communication between viewer and programme (or information) source. Tele-banking, home security, data transmission for business and video telephony have all been promised.

TV by cable is not new. In the 1940s, cables which had been used to 'pipe' radio were used to transmit television in areas where the off-air reception was poor. The terms of licensing for these cable companies required them to carry BBC and ITV (the so-called 'must-carry' rule) and, in most cases, only these channels were carried (with the possible exception of local community television).

Only the relay of out-of-area ITV



1. Various modes of signal distribution in the existing television network.

Right: main control room for SelecTV – cable operators in Milton Keynes. SelecTV distributes the four standard channels, a film channel and their own programmes. The small boxes on top of the two screens on the left and right are the MAAST decoder units. Each subscriber has one of these set-top units to decode the television signals.
(Photo: SelecTV plc).

channels offered viewers a wider choice. About one and a half million households were cabled, but as the BBC and IBA improved transmission, cable subscribers declined.

Another service, **community aerial television** (CATV), operated in the 1970s. This provided a limited amount of locally produced material, notably in Milton Keynes (where roof-top aerials were forbidden) and Greenwich, London. These community services eventually closed, with the exception of Greenwich, because costs were not covered by the number of new subscribers.

In Britain, the early cable networks used twisted-pair cables, one pair per channel, supplying four or six channels per subscriber; later networks, including those set up in the New Towns after 1966, used coaxial cable. Originally, all transmissions were on VHF, but as UHF sets became more widespread, UHF was used for subscriber links and VHF was only used for trunk stages. In the U.S., on the other hand, VHF is long established, and is still used today.

The new pay-TV

In the U.K., then, there was little impetus to upgrade either the technology or the services. Then in 1980, the Home Secretary licensed thirteen cabled areas to run a subscription TV (or **pay-TV**) service of one non-BBC/ITV channel, for around £10 per month. This pilot scheme, licensed until December 1983, was intended to gauge public reaction to a new, subscription-based channel. Operators included Rediffusion, Visionhire and Thorn EMI (Radio Rentals). One fact that emerged was that viewers seemed to like full length films, and this was confirmed by the increase in home video rentals.

Typical programming included a dozen recent films, each repeated several times a month, at different times of the day. Rediffusion reported that subscribers were not only watching the film channel in preference to the other channels, but were happy to watch the same film several times. Entertainment, and specifically all-film channels, now dominate proposed cable programming and therefore financing.

Hunt and after

While this experiment was taking place, the Government commissioned a three-man enquiry, led by Lord Hunt, to look into the

future of broadcasting. The Hunt Committee (1982) was asked to consider how the cable system could be expanded without detracting from established standards of broadcasting, and to provide recommendations for supervising and financing the expansion.

The Hunt Committee report was followed, early in 1983, by a Government White Paper which followed Hunt's recommendations closely, and laid down the framework for the present Cable and Broadcasting Bill which became law in August 1984.

The committee stated that cable television:

> ". . . should be seen as supplementary, and not as a rival or alternative, to public service broadcasting. It should widen and enrich the viewer's choice by providing a large number of channels of special interest for which people are prepared to pay. It should be encouraged to be innovative, experimental and above all responsive to local needs. . ."

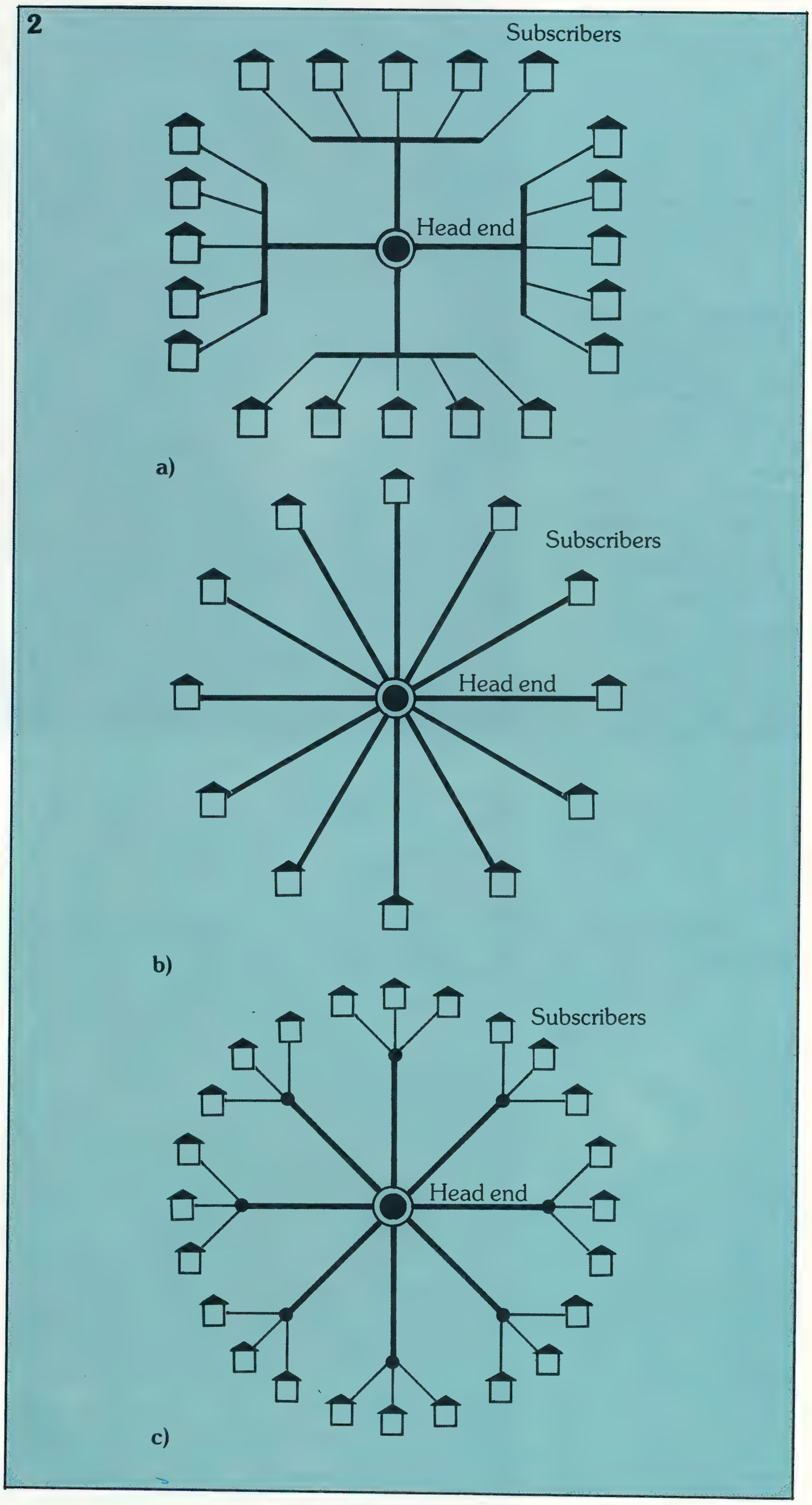
The report identified four classes of operator in a cable television structure: the **cable provider**, who installs and owns the cable system; the **cable operator**, who manages the cable system and decides on programming; the **programme provider**, who packages programmes into channels or sectors for sale to operators; and the **programme maker** (or production company) which produces the programmes.

The cable operator was thus indentified as the main customer for all services, the purveyor to the public, and as the initiator and architect of a cable network in all its technical and financial detail.

Private money is being used to set up services, by awarding local franchises to operators on the basis of the quality of the technical and programming services they propose to set up. These franchises are licensed in such a way that the quality must be maintained, in order to retain the licence.

Hunt laid down no specifications for the type of cable to be laid, only commenting that the provision of a nation-wide system by British Telecom or another contractor would be "inconsistent with the Government's policy on competition".

2



2. Three different types of distribution network: **(a)** tree and branch; **(b)** star; **(c)** switched star.

The White Paper did however state that "coaxial cable and optical fibre will be permitted", and that "the Government wishes to encourage the development of cable systems which will permit the provision both of programme and

The Research House/British Telecom

Above: small, portable dish aerial used for DBS television signals.

interactive services".

The White Paper also specified that cable developers could use either the established tree and branch type distribution (*figure 2a*), or the newer, still experimental, switched star distribution (*figure 2c*), but all cable ducts must be laid out in a star configuration and they must be large enough to allow for future expansion.

Although the Broadcasting Bill does not mention technical standards, leaving all judgements to the newly established Cable Authority in its allocation of licences, the Government has shown that it is looking towards a nation-wide, interactive system, and preference is likely to be given to companies who are willing to provide for this.

The eleven chosen pilot (interim) franchisees delivered a few surprises to those expecting the original cable operators to get preference. Visionhire bid for four areas, and won none; SelecTV, established in Milton Keynes and working with British Telecom, were disappointed; Rediffusion, one of the biggest cable system developers, bid for four areas, and won the smallest franchise – 22,000 homes in Guildford. Visionhire and Rediffusion have since withdrawn from cable TV. As they were, until recently, Britain's biggest cable TV companies, these developments have caused some consternation in the industry.

The Government decided that the pilot franchisees should choose a well defined and consistent local community (Coventry, North Glasgow, the London Borough of Croydon, and the City of Westminster were among the areas chosen). They should also be able to show where their finance was coming from, how it would be managed, and that they are planning towards advanced technology.

Seven of the first eleven franchisees proposed switched star technology; two

Left: control room of the independent SKY Channel Satellite television company. Programmes are distributed by the ECS-1 satellite to over 1.4 million cabled homes in Norway, Finland, Switzerland, W. Germany, Austria and the U.K. (Photo: British Telecom).

others proposed to convert from tree and branch to switched star within a short time. No absolute deadlines were proposed, as the necessary technology is still under development. Full licences will run for 15 years for tree and branch systems, and 20 years for switched star networks.

To protect the universal right to receive broadcast BBC and ITV transmissions, franchisees must provide all four channels, as well as leaving space for two **Direct Broadcast by Satellite** (DBS) television channels (even though the public service channels are available off-air all over the U.K., and DBS potentially so).

As far as future programme content is concerned, the Government has laid down few rules. There are to be no quotas on the use of foreign programmes and there has been no ruling on the use of feature films – although no 'adult' film channel will be allowed to operate.

Films, however, play an extremely important role in the economics of cable television. Each franchised operator proposes to offer services in two or three tiers, for example, a premium 'first run' movie channel might be available for £8 to £10 a month; this to be charged on top of the fee for receiving all other channels – about £6 to £12 per month.

Advertising and sponsorship (the latter banned for the interim period) will of course be very important in the financing of cable TV. Opponents have been afraid that advertising will swamp the new service. Guidelines state that advertising "analogous to ITV and independent local radio (ILR) advertising" should follow the rules laid down by the IBA, while channels *devoted* to advertising and promotions will not (such as W H Smith's interactive channel, Videoline).

Cable TV in Europe

Cable and satellite developments on the continent have been remarkably similar to those in the U.K. France has opted for a combined coaxial and optical fibre system, initially with a star network at the subscriber end and a tree and branch trunk network; each section will be operated by its own switching centres. The second stage envisages a star trunk network, operated by switching at the head end and capable of a fully interactive service. A

third stage, looking ahead of the U.K. at present, calls for two-directional video telephony, with the signal manipulation being entirely digital.

Germany is also looking ahead to a broadband two-way capability allowing video telephone, as well as narrowband communication and one-way broadband information services. At present, cabling is coaxial with only specialised use of fibre optics; a pilot project in Munich is planning to operate a two-cable system allowing 50 to 60 channels (25 to 30 per cable), a scale of delivery normally only associated with the U.S. (In a few areas in the U.S., over 100 channels are available to subscribers.) The Federal Government in Germany is holding back on fibre optic installation until financial and technological conditions are suited to concentrating on adapting the whole system to the more advanced techniques.

Right: British Telecom's switched star cable TV network offers a choice of four subscription services. (Photo: British Telecom).

Cable distribution

Most modern television signals are carried by the UHF band (300 MHz to 3 GHz); older systems, including much of American television, use the VHF band (30 MHz to 300 MHz). In a traditional television system, programme signals are generated by a broadcasting station to be received, by a network of transmitters (see *Communications 4*). In the U.K., some fifty transmitters beam out these signals which are received directly by roof-top aerials in about 85% of homes.

This figure has been raised to 99% by means of local relay stations, to which the BBC and the IBA are continually adding.

There are problems involved in transmitting UHF signals on the air. Any one transmitter has a limited coverage, and a different wavelength is needed to transmit the same channel in adjacent areas to prevent interference. Only a limited number of channels can be transmitted in this way; with cable, on the other hand, the number of channels transmitted is limited only by the number of cables in the duct. A broadband coaxial cable with a bandwidth of around 350 MHz could potentially carry up to 50 channels, but in reality 15 to 30 is

The Research House/Swindon Cable

Above: receiving dishes used by Swindon cable services.

a more likely number.

Many countries are aiming for interactive services. To achieve this, it is expected that the whole network will eventually be cabled up with optical fibre. Optical fibre cable can carry a wider bandwidth than coaxial, is much less bulky, and loses far less signal by attentuation – needing repeater stages about every 30 km, as opposed to 2 to 3 km for coaxial (see *Communications 1* and 10). The extra capacity of optical fibre cable means that a substantial volume of two-way traffic can be carried.

As we have said, it has been recommended in the U.K., that all new networks should be laid out in the star configuration; previously, most have been in a tree and branch arrangement. As we can see from *figure 2*, in tree and branch networks the signals are fed out from the **head end** (which usually receives its signals from a telecommunications satellite via an aerial array or dish) through a trunk cable. In turn, smaller cables branch off via signal splitting units (known as **taps**), taking a proportion of the signal to local areas; these then split down into subscriber links.

Optical fibre cannot be tapped in the same way, so tree and branch distribution needs to use coaxial cable. All subscribers receive one package of channels, and can only be prevented from receiving premium channels by a set-top unit which decodes protected signals only after payment – as we shall see later.

The star structure, on the other hand, feeds signals from the head end, down trunk lines to local distribution points, from each of which a star of links is fed to subscribers.

Star allows the use of optical fibre as it becomes practical to decode the light pulses which carry the signal, at the distribution points, and regenerate them with lasers for supply to individual homes. Coaxial cable can also be used for all or part of the system, with the possibility of upgrading to optical fibre, section by section.

From here, it is a natural step to adapt the distribution points as switching points, allowing subscribers to receive only paid channels. Selective switching of TV and telecommunications is the factor which will make interactive services possible.

Satellite television

Meanwhile, what of satellite television? Satellite transmission will play a vital role in cable TV as it provides the link between the point of origin and the head end of the cable network. Direct broadcast by satellite (DBS), however, could either be a counterpoint to cable TV, or a direct competitor, depending on the kind of programming it offers.

The progress towards DBS in the U.K. began in Geneva in 1977 with WARC '77, the World Administrative Radio Conference arranged by the International Telecommunications Union and attended by delegates from 111 countries. At this meeting, orbital positions and satellite frequencies for Europe were allocated; each state received five channels.

However it was not until 1981 that the Home Office actually published a paper encouraging the development of satellite broadcasting, and in the same year the BBC began to talk about sustaining two channels. Significantly, one of these was to be a 'quality' channel, and the other was to show recently released films.

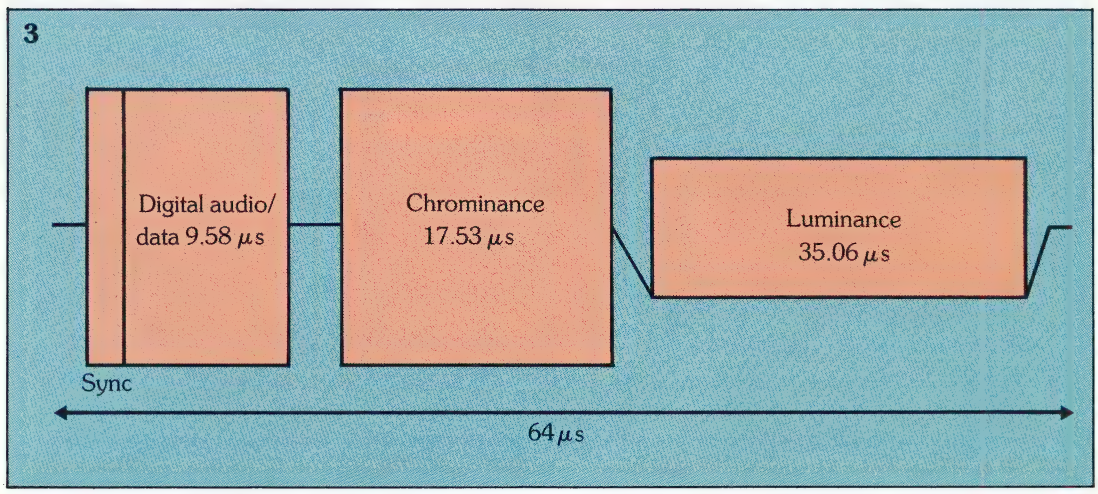
In 1982, the BBC was the first to receive an allocation of two DBS channels. In November 1982, the Advisory Panel on Technical Standards advised the government to adopt a new transmission standard, C-MAC, for DBS. C-MAC (a type of time division multiplexed analogue component signal) was developed by the IBA, and **Extended PAL** (E-PAL), the BBC's submission, was rejected.

The choice of standards had financial as well as technical implications. C-MAC and E-PAL are both designed to exploit the 27 MHz bandwidth allocated to DBS channels.

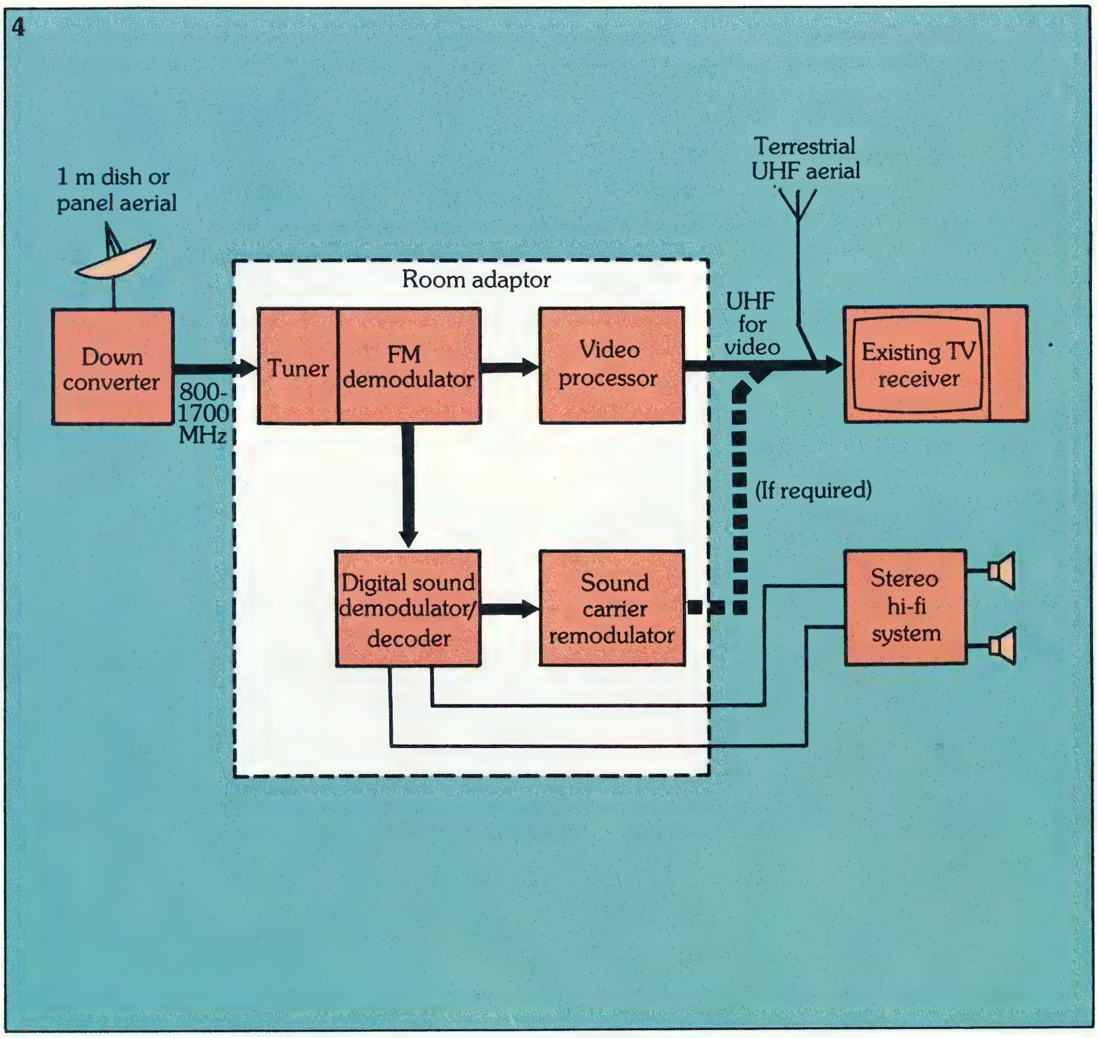
C-MAC uses digitised audio information. The audio signals directly modulate the same radio frequency carrier modulated by the vision signals. C-MAC transmissions allow a maximum of eight digital high fidelity sound channels. Two of these can be used for stereo television sound, while the others can be employed for audio or data transmission.

A digital process is used to multiplex the sound and vision signals. *Figure 3* illustrates the different components in a C-MAC signal, which uses a 64 μs time slot. Unlike the PAL colour systems which transmit chrominance as an extension of the luminance signal (see *Communications 4*), the C-MAC system transmits chrominance and luminance separately. This is one main reason why DBS will produce higher quality pictures than the existing PAL system.

C-MAC was recommended by the Part Committee as a new start, tailor-made to DBS's power efficient FM (frequency modulated) technology, and suited for conversion to **high definition television** (HDTV) in due course. HDTV will need around 1000 lines of picture and up to 30 MHz of bandwidth. It was argued that C-MAC avoided the colour problems to which PAL is prone, survived cable transmission better, and was more consistent with current TV set design than E-PAL.



3. The different components in the C-MAC signal which uses a 64 μs time slot. The chrominance and luminance signals are transmitted separately, producing very high quality pictures.



4. Stages in translating a DBS signal for the UHF receiver.

The BBC (and the cable operators) argued that it would be too expensive to opt for a completely new system when the public's response to the new forms of television was, as yet, ungauged.

It was hoped that Europe would see in C-MAC the basis for a new European standard. This hope however has been disappointed. C-MAC's bandwidth is actually too wide to transmit down many existing French cable systems. The French are developing their own version of C-MAC, D2-MAC, which has a narrower bandwidth.

The continued indecision, coupled with other problems, led the BBC to talk, again, about withdrawing from DBS altogether. They were unsure of being able to raise the money needed (they are not authorised to use licence fees for DBS). Also, their agreement to lease three transponders (the devices which receive and retransmit the actual signals) on a Unisat 1 satellite is beginning to look uneconomic.

Unisat 1 will be supplied by United Satellites, a consortium, involving GEC-Marconi, British Telecom and British Aerospace, the prime contractors for most of Europe's communication satellites including Olympus (L-Sat) and the forthcoming Intelsat IV. At the moment, the BBC is compelled to deal with Unisat.

As a partial solution to the technical and financial risks inherent in DBS, the government has now proposed a joint effort between the BBC, the ITV companies, and five third parties. The scheme will run for no more than 10 years and will cost an estimated £400 million. In late 1984 the various ITV companies have yet to decide whether to participate, and the launch data of 1987 looks unlikely.

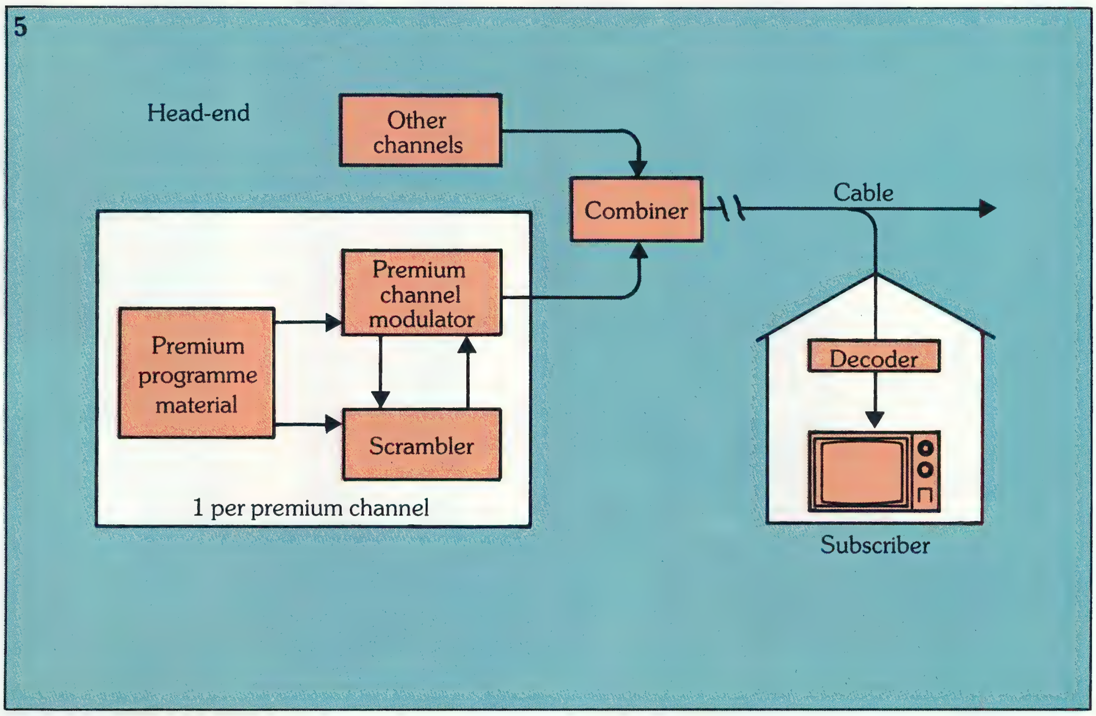
Even so, several DBS channels (three of which are British) already operate in the

U.K., and more are planned. The conclusion is that the U.K. must participate, one way or another, or lose both profits and prestige.

The satellite location awarded to the U.K. is 31° West, with channels 4, 8, 12, 16 and 20, polarised right-handedly. Spain, Portugal, Ireland and Iceland share the same orbital location. A down-link frequency of 12 GHz will be used to carry signals to individual receivers. This super high frequency allows the use of the very wide channel bandwidths which have been

their compactness and ease of use.

After it has been received by the aerial, the DBS signal will pass through stages not unlike those of a cable signal. The extremely high satellite frequencies will be converted down to UHF for transmission, via cable, to the receiver (*figure 4*). At the receiver, a tuner will select the desired channel, a demodulator will sort out sound and video signals from the carrier, and a decoder will convert the signals into the form which the receiver can accept.



5. A passive coding and decoding system. Each subscriber has a set-top descrambler which decodes the premium channel signal. Repossessing the decoder cuts off access to the premium channel without interfering with the four standard channels.

allocated to direct broadcast by satellite TV.

Satellites can only supply comparatively low powers from their solar cells – typically around tens of watts, while a terrestrial transmitter can output a megawatt. It is planned to use high power satellites for DBS, as opposed to the very low power telecommunications type, but improved aerials may make this unnecessary.

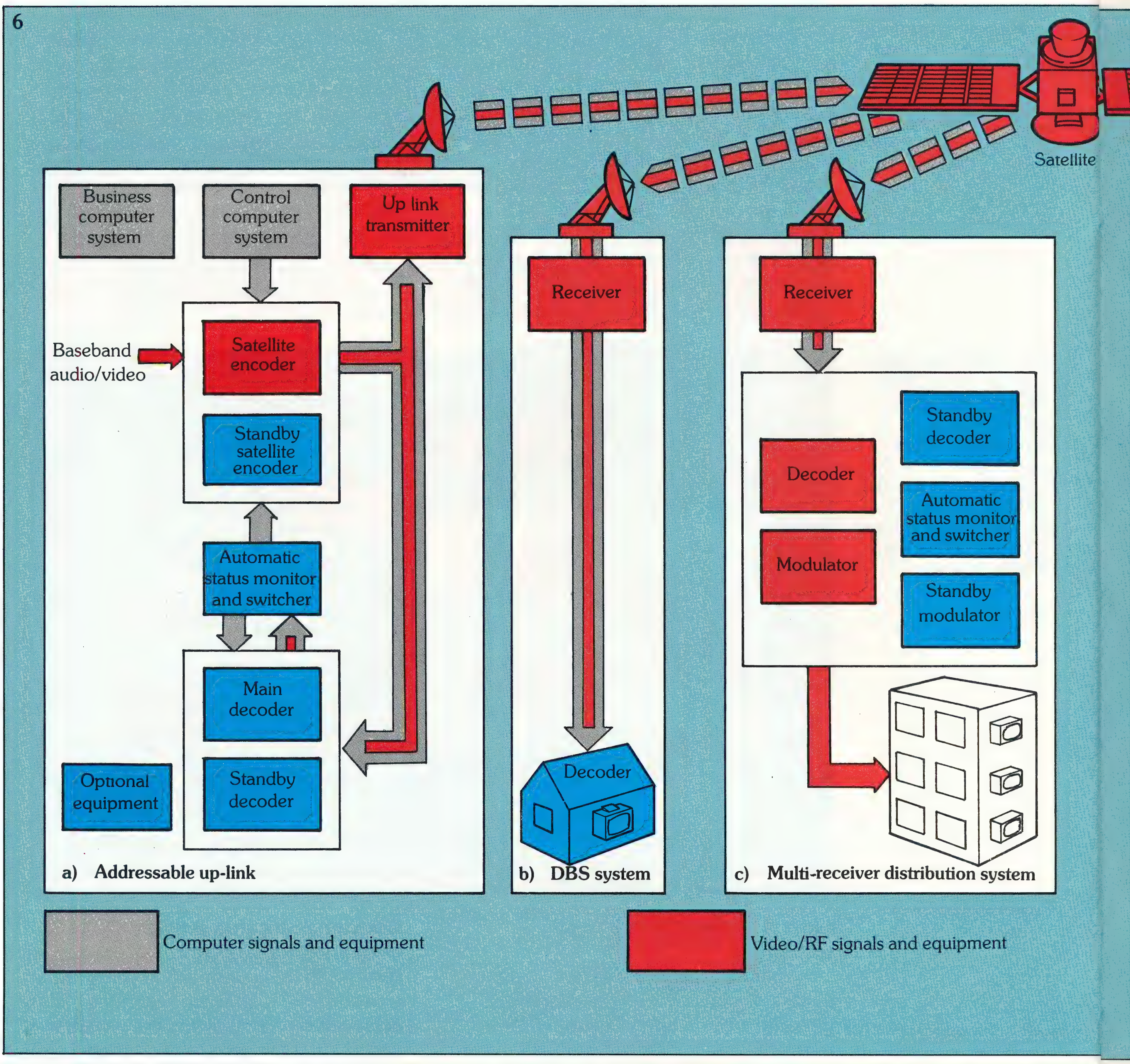
It is likely that groups of houses, and blocks of flats, will be fed by a communal aerial, which will be planar (flat) and able to receive signals from a wide sector of the sky without refocusing. Planar aerials are difficult to design and engineer, but they have the advantage over dish aerials in

Satellite and cable security

Obviously, for satellite and cable television systems to be economically viable, they must be able to enforce payment. This is achieved by not allowing the viewer to watch, until the service or channels desired are paid for.

However, it is not really as simple as all that. The television operators have to prevent unauthorised viewing *and* ensure that legitimate customers are fairly charged.

Until recently, unauthorised channels could be *filtered* in one of two ways: negative filtering involves the use of a set-top filter which suppresses those channels that the viewer is not allowed to see; positive filtering uses a central switching

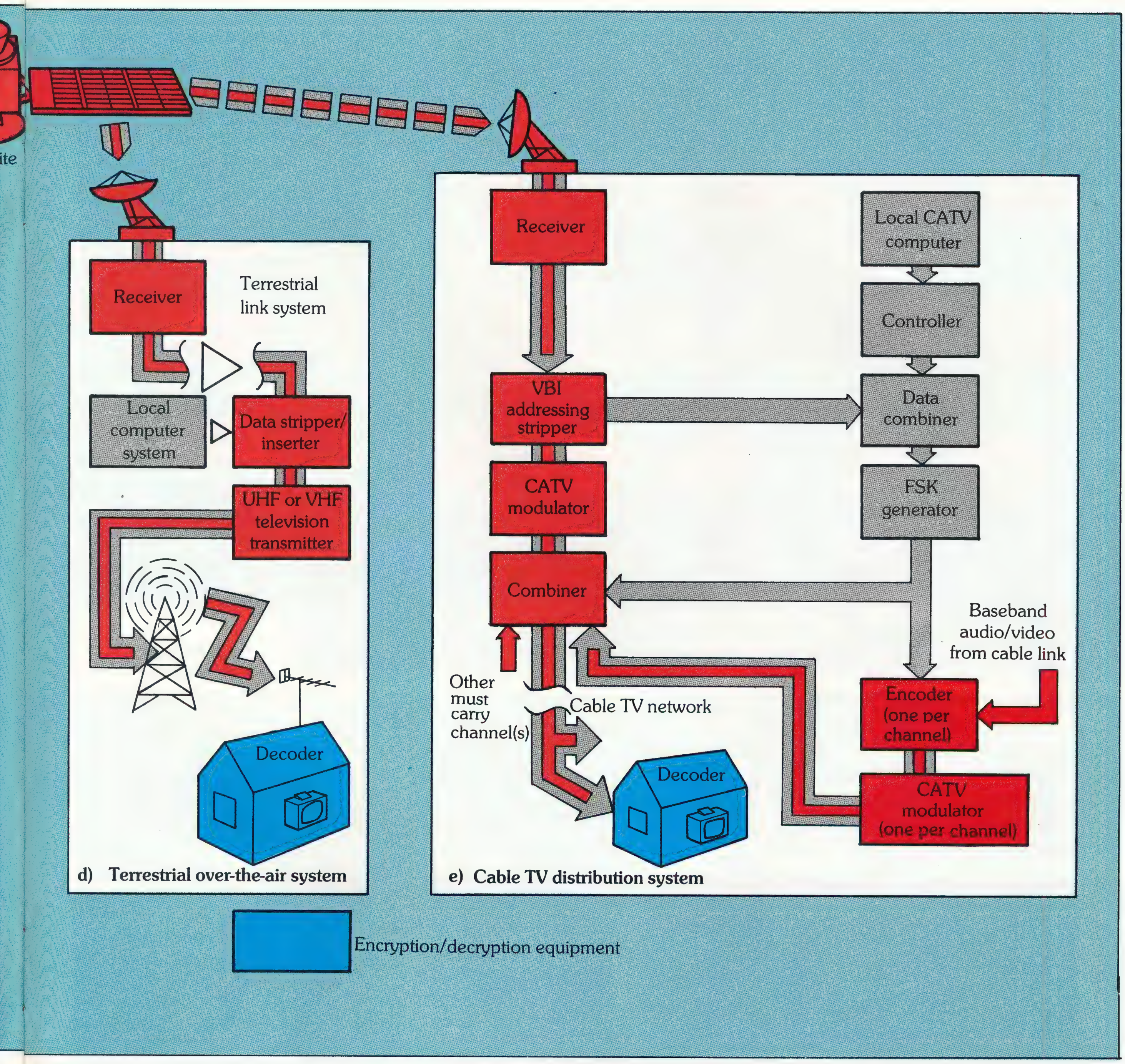


6. Active, addressable pay-TV systems offer a higher level of security than passive systems. Here we see such an active system adapted to five different methods of distribution.

point to pipe only authorised channels to the subscriber. Positive filtering is more costly than the use of a set-top filter.

U.S. cable operators are estimated to lose 30% of their potential revenue through illegal tampering with users' equipment. Complex security systems have therefore been developed to cope with this problem.

Figure 5 illustrates how one of the simplest coding and decoding systems works. This device allows a pay-TV company to operate one 'premium channel' – like a film channel. Each premium channel subscriber is issued with a small descrambler which fits behind the TV receiver. This device decodes the premium channel which is scrambled at the head end – as you can see in the diagram. If subscribers' subscriptions lapse, then repossessing the descrambler effectively cuts off the premium channel (as without it that signal is



completely unviewable) but the other ordinary channels can still be received.

The next stage up from this simple one channel device allows for up to 30 pay TV channels to be scrambled, while still allowing viewers to receive the ordinary 'free' channels if they do not have a decoder unit. Again, this is a passive system and non-payment is prevented by repossession of the descrambler.

Moving along from these passive security devices, the most up-to-date pay-TV systems use active 'addressable' systems. Such systems are especially useful for satellite TV as consumer units can be activated or deactivated from a control centre: in other words, they are addressed by the control centre.

The electronics company Racal-Oak introduced the first addressable computerised pay-TV security system in 1977. This system is adaptable to over-the-air sub-

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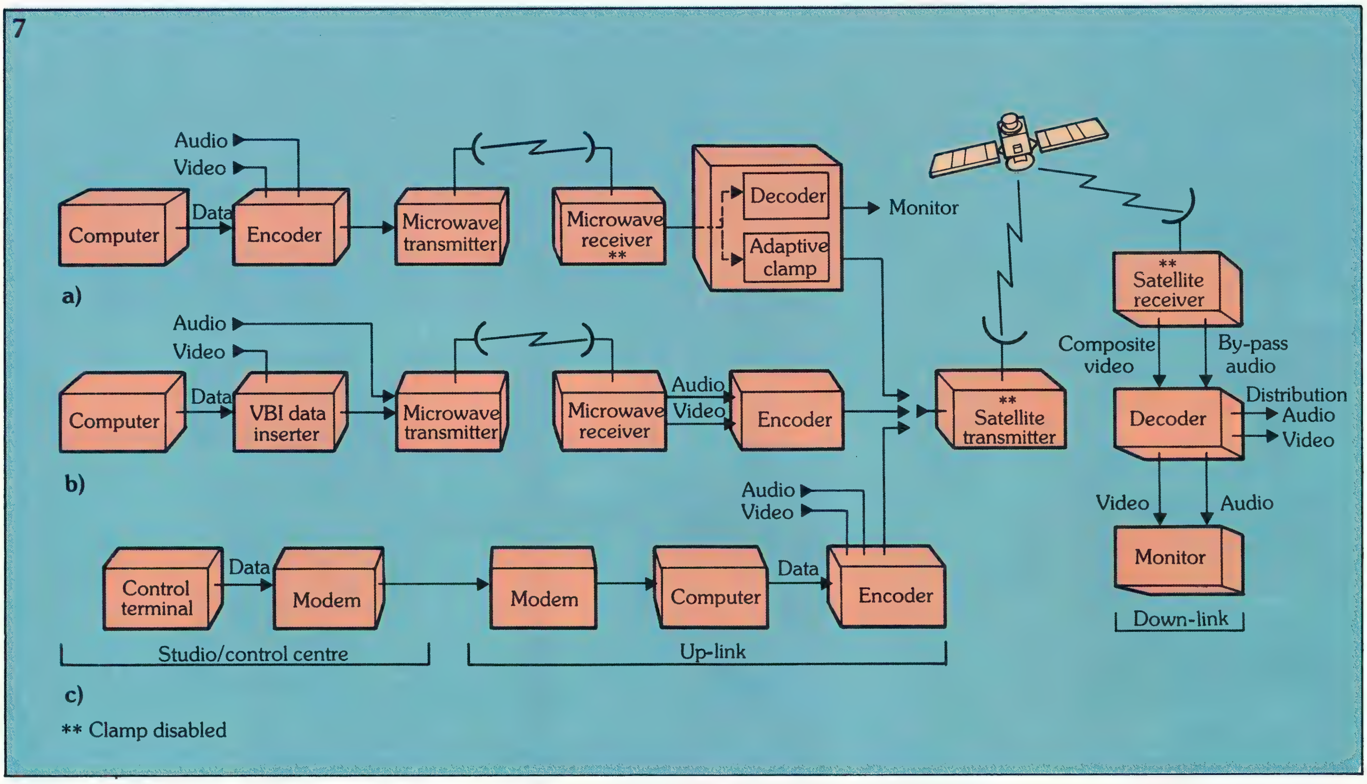


scription television, cable television and satellite distribution systems, and utilises set-top decoder modules (*figure 6*).

A control computer, a business (billing) computer and an encoder are used at the control centre. Unauthorised viewers receive a severely scrambled, unsynchronised video signal and no sound at all. Even if an unauthorised viewer has a decoder unit, it will not decode the signal until it has been addressed and turned on by the control centre.

Figure 7 shows the three different ways in which this system can be used in a satellite TV application. The entire computerised base system handles every aspect of the operation from authorisation to billing the customers.

7. Computerised addressable pay-TV security system used in satellite TV applications: **(a)** encoded terrestrial transmission; **(b)** clear terrestrial transmission; **(c)** telephone line data modem.

Left: the set-top decoder (top of picture) is provided for access to W H Smith's cable service – Videoline. This promotional service offers company sponsored videos, films and long commercials (known as informercials). The microcomputer enables access to a fully interactive games channel. (Photo: W H Smith).

Right: British Telecom satellite receiving dish at Goonhilly downs.

The Research House/British Telecom

Glossary

CATV	community aerial television
DBS	direct broadcast by satellite
HDTV	high definition television
head end	the place where signals are originated, processed and controlled for distribution over a cable system
security system	system of encoders and decoders used to scramble television signals

16

MICROPROCESSORS

Dissecting a micro

Microprocessor based computers

Throughout this series on microprocessors we have looked in depth at the microprocessor itself – the IC which performs the central processing activities within microprocessor based equipment. Our study has guided us through the principles of control, addressing, timing, instruction sets, programming etc. with particular reference to computer applications. However, we have not yet looked at the microprocessor based equipment itself.

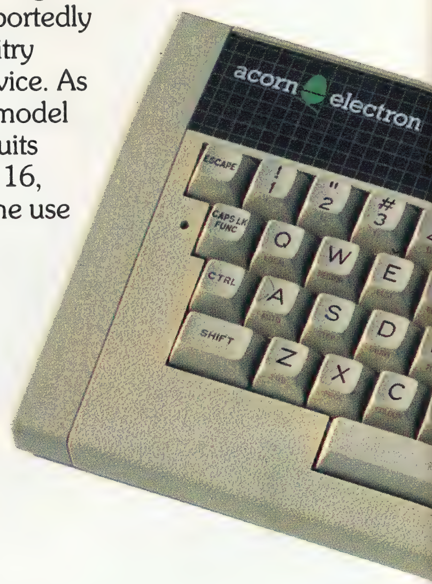
This concluding chapter on microprocessors aims to illustrate how two well-known microprocessor based computers are constructed, and discusses how the separate parts of each computer combine to make the whole.

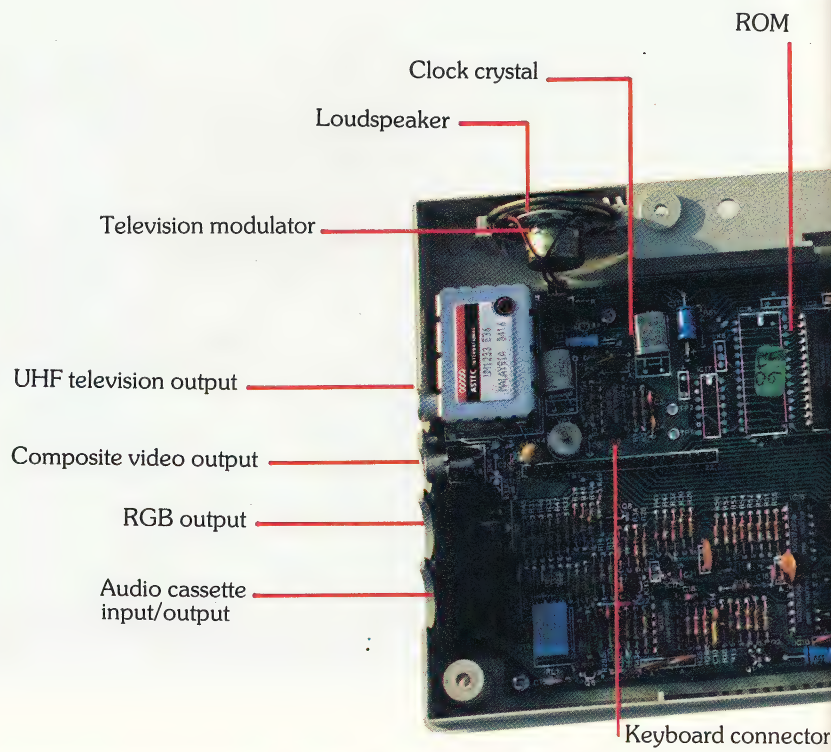
The Acorn Electron

The Electron is manufactured by Acorn, the same company which designed and makes the familiar BBC Micro. Most of the facilities and features available on the BBC Micro are incorporated in the Electron, but as it was designed as a smaller and cheaper computer, the Electron is not quite as versatile. It does, nevertheless, represent good value for money.

The microprocessor used in the Electron is the 6502 – an 8-bit microprocessor with a 16-bit address bus allowing it to directly address up to 64 Kbytes of memory. There is a single ROM IC of 32 Kbytes and four RAM integrated circuits, also totalling 32 Kbytes. Data is written to and read from RAM in ½-byte words – a slightly unusual manner which slows down the potential processing speed of the microprocessor.

One of the significant differences between the Electron and the BBC Micro is the Electron's size – or rather lack of it. The reduction in size (by about half over the BBC Micro) is mainly due to the use of a single integrated circuit – which takes the place of many in the BBC computer. This integrated circuit is a programmable logic array (see *Digital Electronics 25*) reportedly having the greatest amount of circuitry programmed into it, of any such device. As a point of interest, the BBC Micro (model B) has more than 80 integrated circuits while the Electron has a total of just 16, and this reduction is due totally to the use of the programmable logic array.





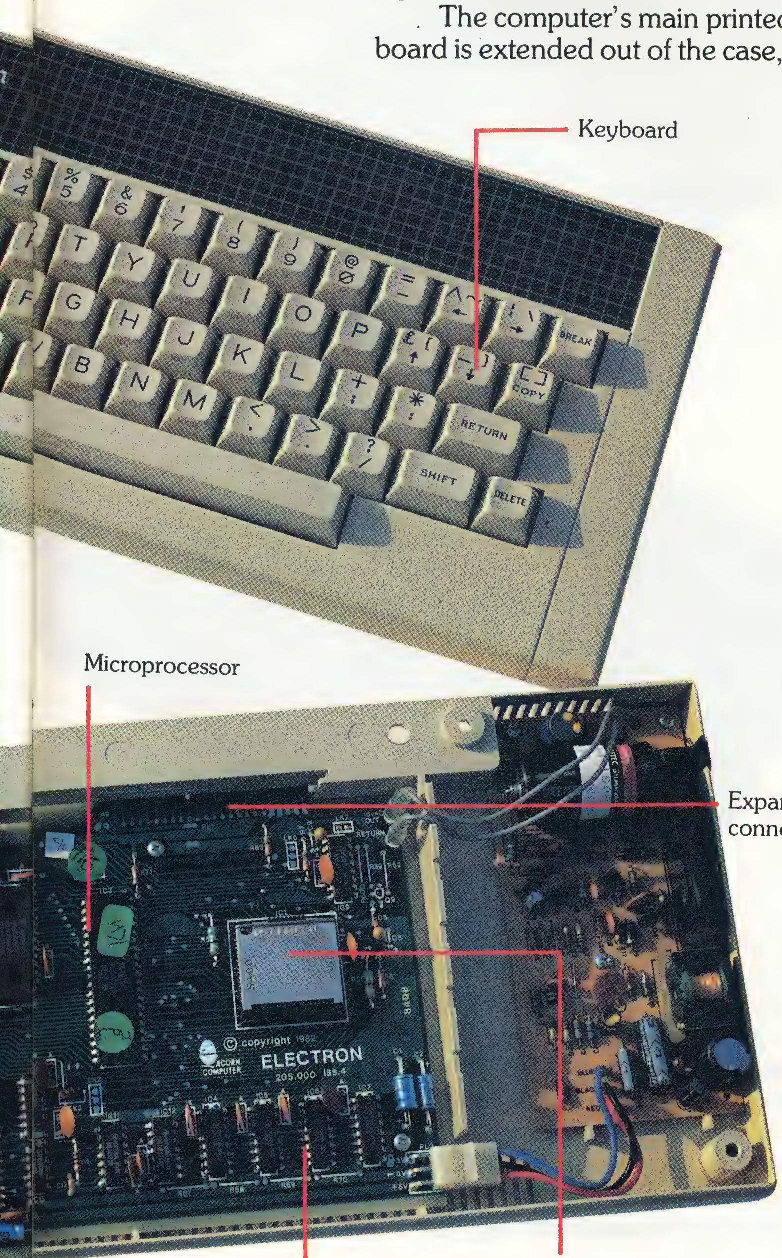
Below: the Acorn Electron.
(Photo: The Research House).

Interfaces

As usual with modern microprocessor based computers, the Electron is complete with a number of input/output connectors. There are three sockets used for display purposes:

1) an ultra high frequency (UHF) signal, modulated for direct input into the aerial socket of a standard television receiver;
2) a red, green, blue (RGB) output, for direct input to a colour monitor with a TTL-compatible input stage;
3) a composite video output, for direct input to standard video monitors; and a socket allowing connection to a standard tape recorder, cassette or reel-to-reel.

The computer's main printed circuit board is extended out of the case, at the rear, and a number of gold-plated tracks on this extension provides a means whereby external devices may be connected. The tracks on the extension are spaced at 0.1″ pitch on both sides, so a standard 2 by 25 way, 0.1″ pitch edge connector will push on. Acorn plans to introduce a number of expansion modules such as printers, disk drives, second processors etc. which will connect to the Electron by this method.



Programming

The Electron is supplied with an internal BASIC assembler program which allows the use of BBC BASIC, a dialect of the high level programming language BASIC (used by the BBC Micro). Electron BASIC is an enhanced version of BBC BASIC.

Both Electron and BBC BASIC contain a feature which allows users to make up commands. These commands, known as **procedures**, must be defined initially in a program and then may be called up later.

A number of the keys on the keyboard are used as **single entry keys** for programming BASIC **keywords**, i.e. pressing a single key causes a complete command to be input.

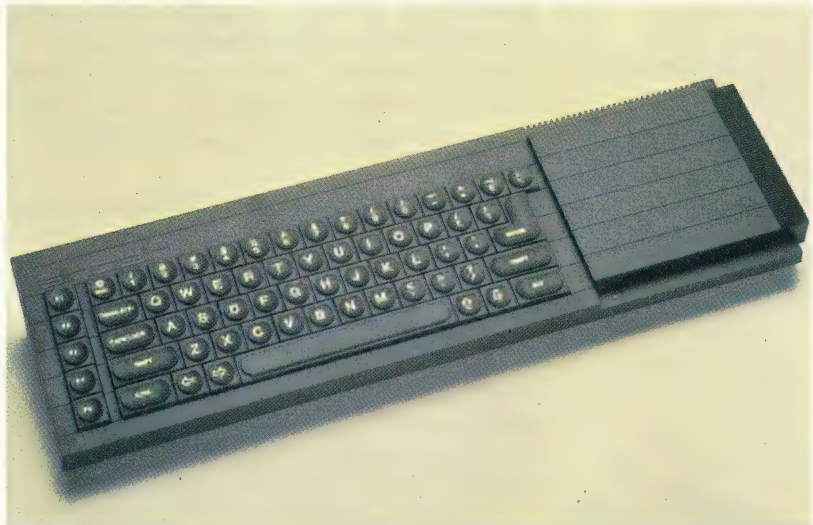
It is also possible to program the Electron in machine code. This allows programs to be executed at higher speeds as there is no need for BASIC programs to be first assembled before execution.

Visual display

The Electron has seven different display modes (Mode 0 to Mode 6) enabling a choice of up to 32 rows of 80 characters, up to 16 colours, and up to 640 by 256 graphics pixels, depending on the modes used. No single mode allows a display of the maximum number of rows, characters, colours and pixels, however, and choice of a display is generally a trade-off between required numbers of each.

Another factor which may influence the choice of display mode is caused by the display's RAM requirements. In Mode 6, for example, the display requires 8 Kbytes of RAM whereas Modes 0, 1 and 2 use 20 Kbytes of RAM. The amount of RAM used by the screen display in turn obviously affects the remaining RAM space used for user programs.

The Sinclair QL

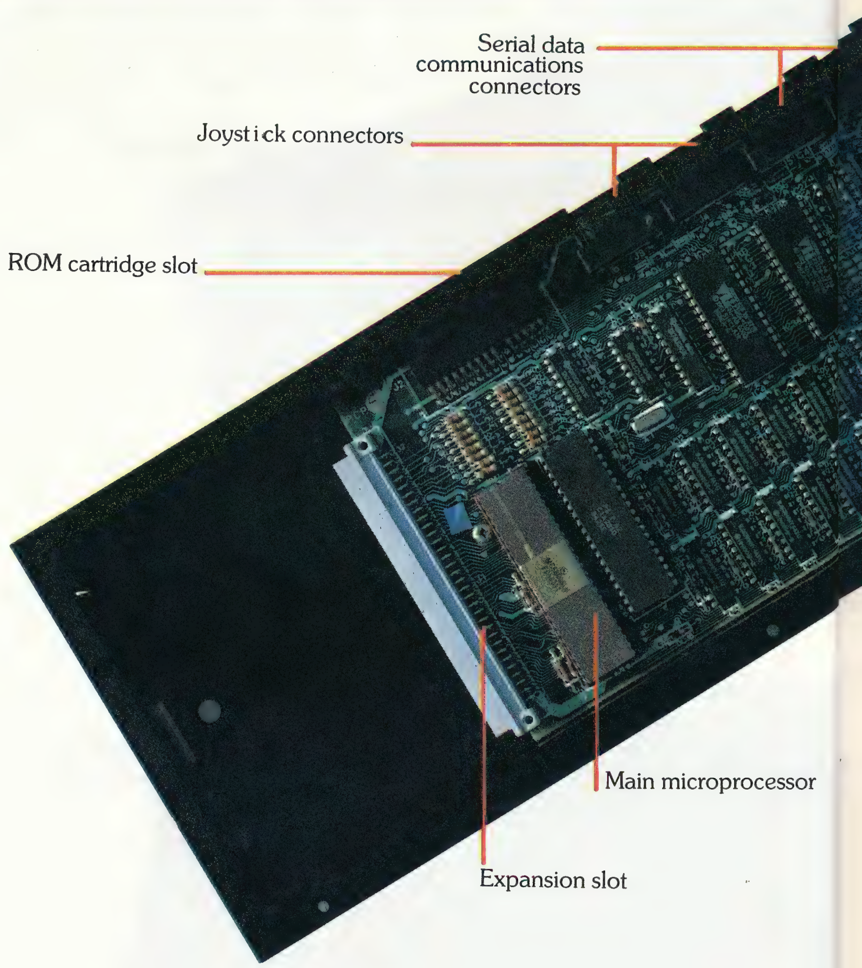


The Sinclair QL (Quantum Leap) is intended as a business *and* home computer. Its central processing microprocessor is the 68008, a 32-bit microprocessor with an 8-bit data bus (see *Microprocessors 14*) and a 20-bit address bus. An address bus of this size allows up to 1 Mbyte of memory (i.e. 2^{20}) to be directly addressable by the computer. Such a large address space makes possible a wide range of peripheral devices and enhancements. Many peripherals are, in fact, planned by Sinclair, including a 0.5 Mbyte memory expansion board and a Winchester disk interface.

32 Kbytes of ROM storage (expandable to 64 Kbytes with the use of a peripheral ROM cartridge, plugged into a slot at the back of the case) are supplied with the QL, as is 128 Kbytes of RAM. It is planned that firmware, in the form of ROM cartridges, will be available shortly. A portion of the RAM (32K) is dedicated for use as screen display storage so this leaves 96 Kbytes of user available RAM.

There are four Sinclair designed integrated circuits within the QL. The first controls the display and memory; the second controls major peripheral interfaces; the third and fourth provide certain analogue functions.

A second microprocessor, an 8049, controls keyboard functions, sound generation and serial data reception, leaving the main microprocessor free to execute user programs.



Auxiliary storage

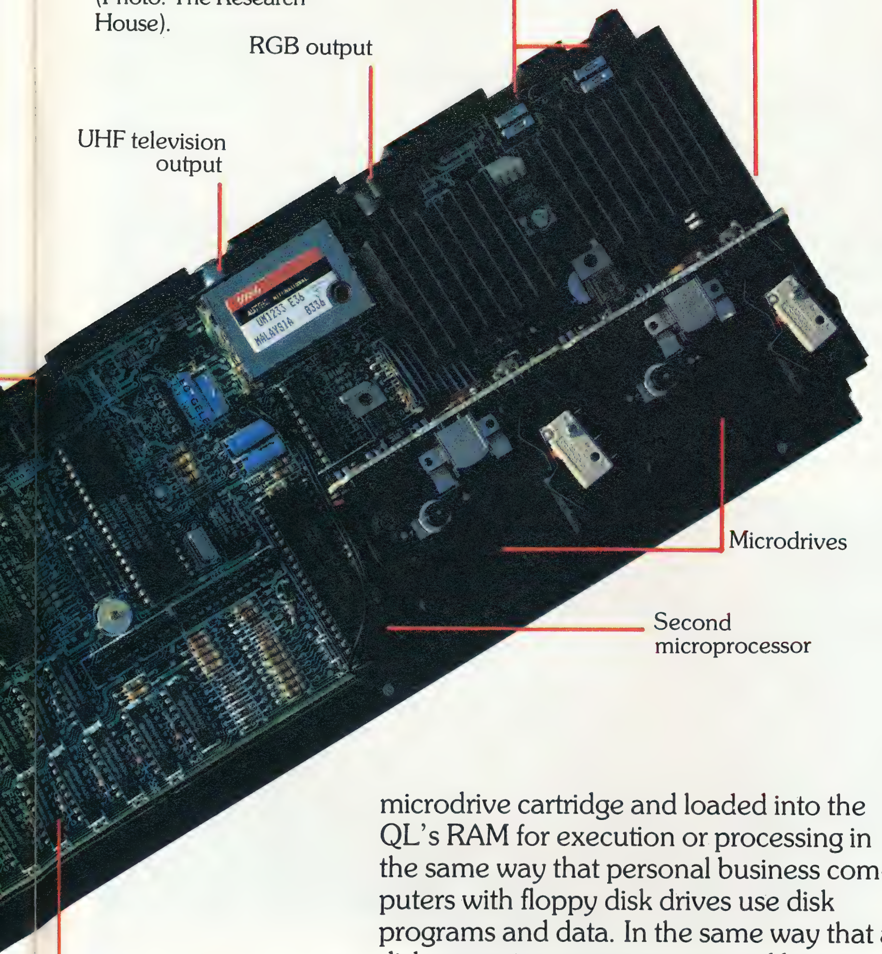
Most home computers use cassette tape storage as a standard method of providing auxiliary storage. Writing data to and reading data from cassettes can be a long and involved task, fraught with errors and problems. The QL is different in this respect as it features two integral tape-drive mechanisms (called **microdrives**) capable of writing data to and reading data from **microdrive cartridges** much more rapidly.

Each microdrive cartridge is capable of holding up to about 100 Kbytes of data, on a tape-loop which takes about seven seconds to run completely. The QL's microdrive storage system is thus similar in operating principle to, although slower than, floppy disk storage systems common on personal business computers. A further six peripheral microdrives may be attached to the QL, allowing access to a very large bank of auxiliary storage.

Programs and data can be held on

Left: the Sinclair QL microcomputer. (Photo: Sinclair Research).

Below: the printed circuit board inside the Sinclair QL. (Photo: The Research House).



microdrive cartridge and loaded into the QL's RAM for execution or processing in the same way that personal business computers with floppy disk drives use disk programs and data. In the same way that a disk operating system is required by a business computer, therefore, an operating system is required by the QL to control the microdrives.

Operating system

The QL's operating system is known as QDOS, and is supplied in ROM along with the Sinclair dialect of BASIC known as Sinclair SuperBASIC. These two integral programs mean that the QL is ready for use from the instant of switching on, allowing rapid loading and execution of programs, in a way unobtainable from any computer of a comparable price.

QDOS is a **multiple tasking** operating system, which allows several programs to be executed simultaneously. It enables multiple windows to be displayed on the screen during execution of programs, the results of individual programs displayed in selected windows.

One further useful feature of the QDOS operating system is that inputs and outputs are **device independent**, i.e. programs are written without reference to the type of device to be used for input/output: the device is specified when the program is executed.

Sinclair SuperBASIC is used as the QDOS command language so the system is easily accessed by the programmer. SuperBASIC, like Electron BASIC and BBC BASIC, allows definition of procedures.

Previous Sinclair computers have been notorious for their inadequate keyboards. With the QL (and the ZX Spectrum +) Sinclair has put matters right by incorporating a full-sized keyboard of reasonable quality, number of keys and functions.

Interfaces

The QL has been designed to allow a significant amount of expansion and input/output. For these purposes there are a number of connectors:

1) an expansion slot, formed by a 2 by 32 way edge connector on the printed circuit board. This accepts the planned 0.5 Mbyte memory board or the Winchester disk interface;
2) the ROM cartridge slot;
3) two inputs for joystick controls;
4) two serial RS-232C (i.e. V.24) ports for data communications;
5) a UHF television output;
6) an RGB monitor output;
7) two connectors allowing the QL to be interfaced to local area networks of up to 64 QLs or Spectrums;
8) microdrive extension slot.

Software

Four software packages are supplied with QL, in the form of microdrive cartridges. These are typically business oriented packages of word processing, spreadsheet, database management and graphics origin, allowing interactive use and file generation. Data may also be moved from one package to another.

23 COMMUNICATIONS

SatStream

Satellites

Often, a single advance in one technological area has far-reaching effects in many related areas. As far as communications technology is concerned, no advance has been more significant than the advent of satellites and their consequent use as transponders – receiving and transmitting communications around the world.

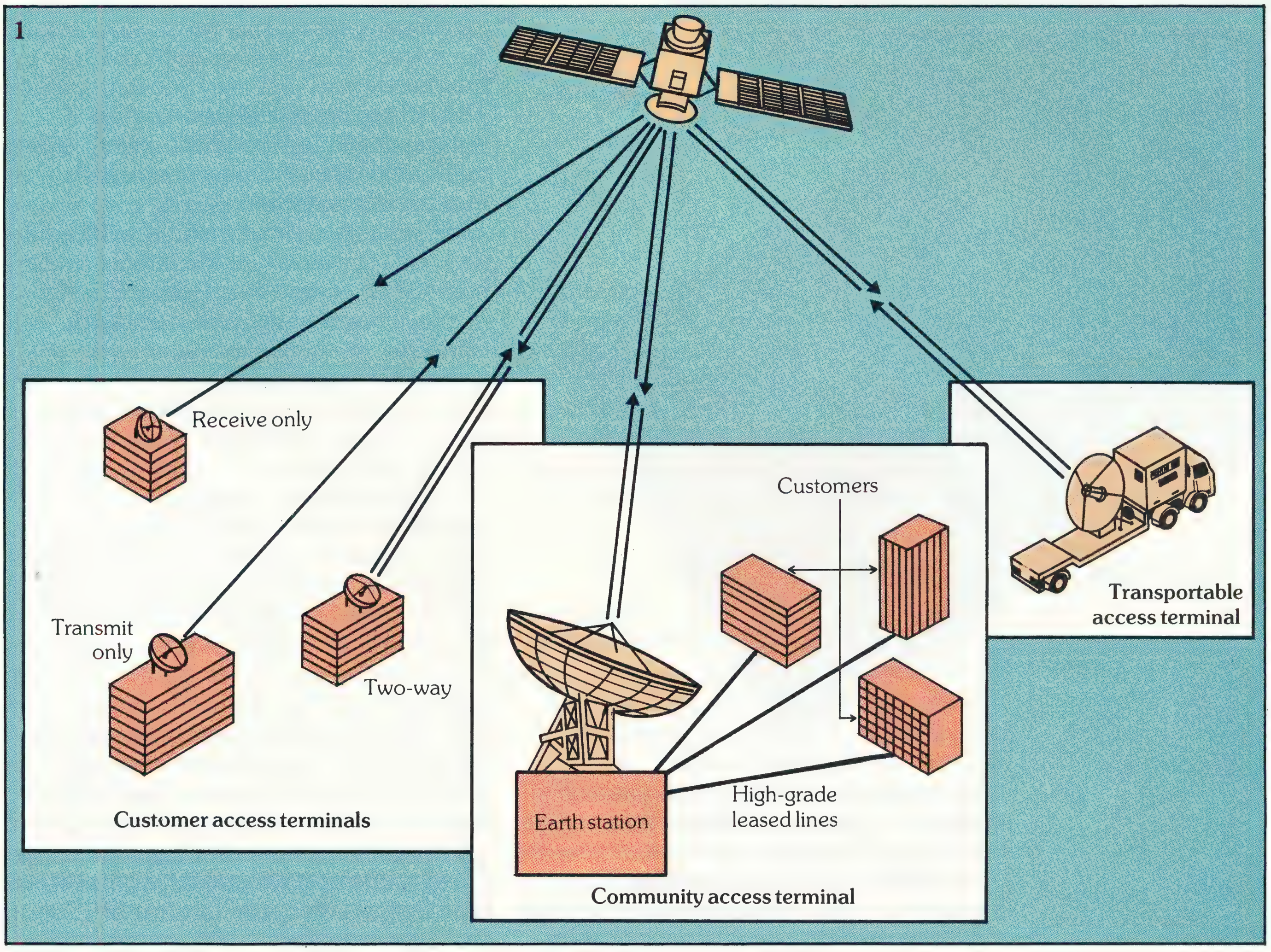
Although their enormous potential for global telecommunications is being utilised, a few drawbacks have prevented their widespread use in small-scale communications systems, such as those required by business.

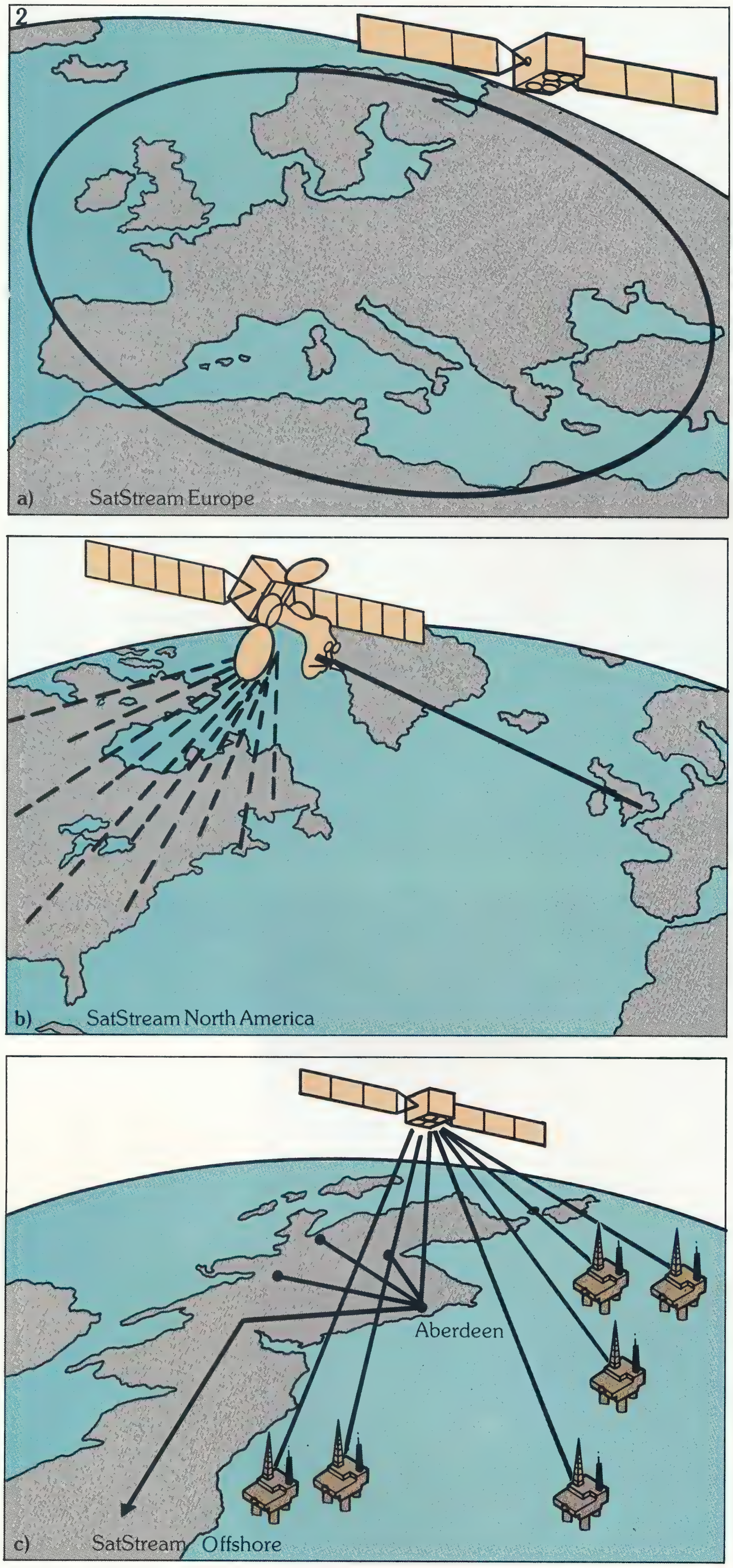
For example, satellite communications in the past have relied on large dish aerials, often up to 30 m in diameter, for transmission and reception of quite low frequency microwaves. To prevent interference with earth-bound radio communications, aerials of this size are usually located at earth stations, well away from heavily populated areas. This is not an ideal situation, however, as many ground

1. Various options for access to British Telecom's SatStream service.

2. The three SatStream communications services – divided according to their zones of coverage.

1





links need to be connected to the earth stations to cope with and distribute the large number of communications channels.

Recent developments in the use of higher frequency bands have resulted in the need for smaller dish aerials and the elimination of interference problems. British Telecom International (a division of British Telecom) has recently set up a satellite communications network – **SatStream** – in which small dishes, of between 3.7 m to 5.5 m diameter, are easily located on roof-tops in city centre sites, thus providing ideal access to satellite communications techniques for many organisations.

Indeed, the dishes and equipment are so small that it is even economical to transport them to remote sites, such as oil rigs, or to move them around to temporary locations, to cover sports meetings for example.

The variety of options available for access to the SatStream services are shown in *figure 1*. As we can see, access terminals may be conventional satellite earth stations with multiplexed transmission and reception of customers' communications. These earth stations provide all multiplexing and demultiplexing requirements, and are connected to customers' premises via a high grade leased line and baseband modems (see *Communications 13*).

Alternatively, customers may have an access terminal mounted on the roof of their own premises, providing one-way (receive only, or transmit only) or two-way communications.

Finally, the transportable access terminal may be moved from site to site, responding to demands for urgent or temporary communications links.

Satellite coverage

SatStream communications services are divided according to their zones of coverage. As *figure 2* shows, there are three areas:

1) **SatStream Europe** (*figure 2a*). Communications links between sites *anywhere* within this coverage zone are potentially possible.

2) **SatStream North America** (*figure 2b*). This service initially opened with a link

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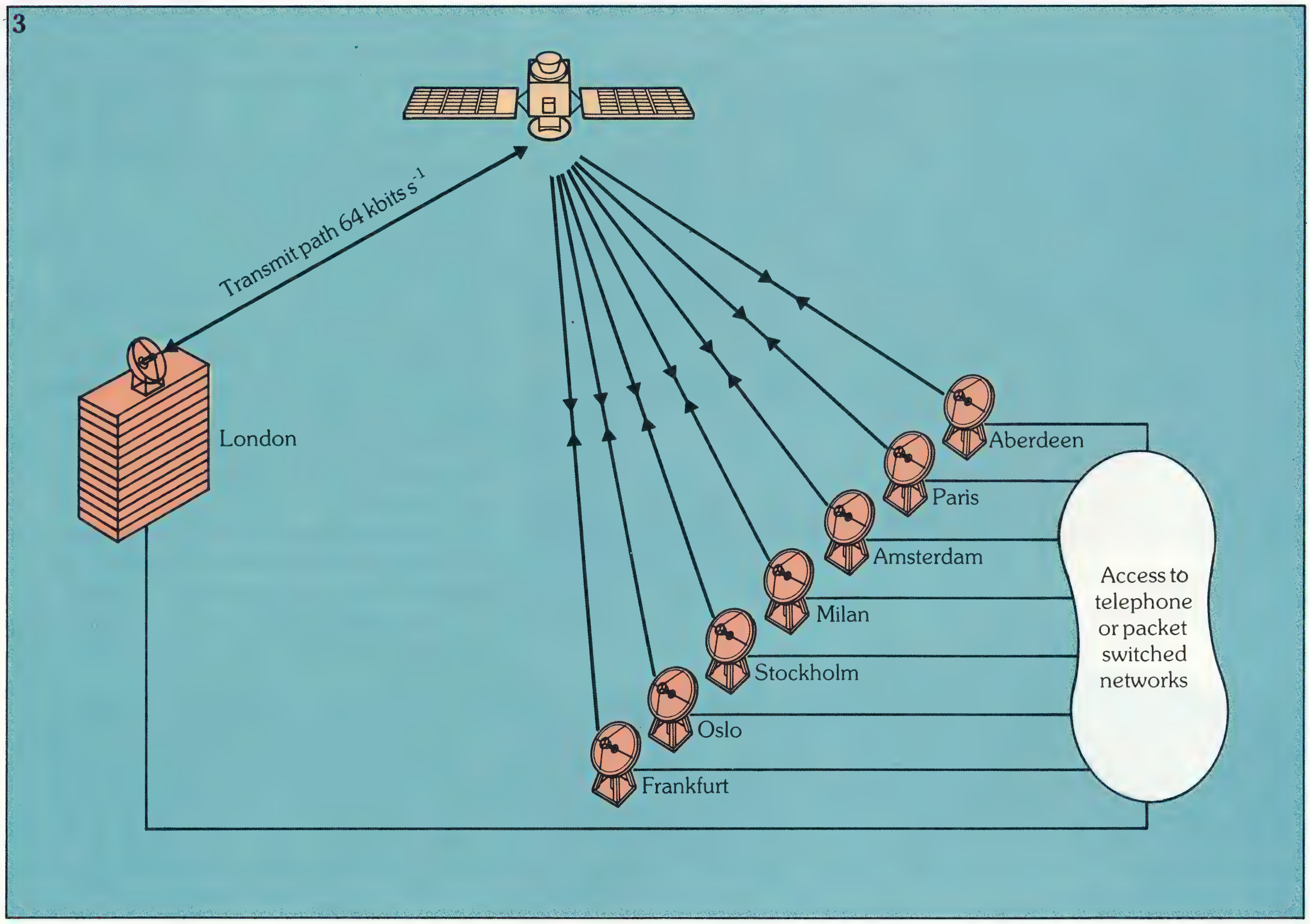


3. A simple point-to-multipoint network.

between the U.K. and Toronto, Canada, in February 1984. Progress is being made towards extending transmission to other cities in Canada and to the U.S.

One of the first applications for SatStream North America was a video **teleconferencing** facility linking customers in North America and the U.K. via on audio/video link. This useful service enables business conferences to take place without the need for all parties to be present in the same office – video teleconferencing is an inexpensive alternative to flying personnel from continent to continent.

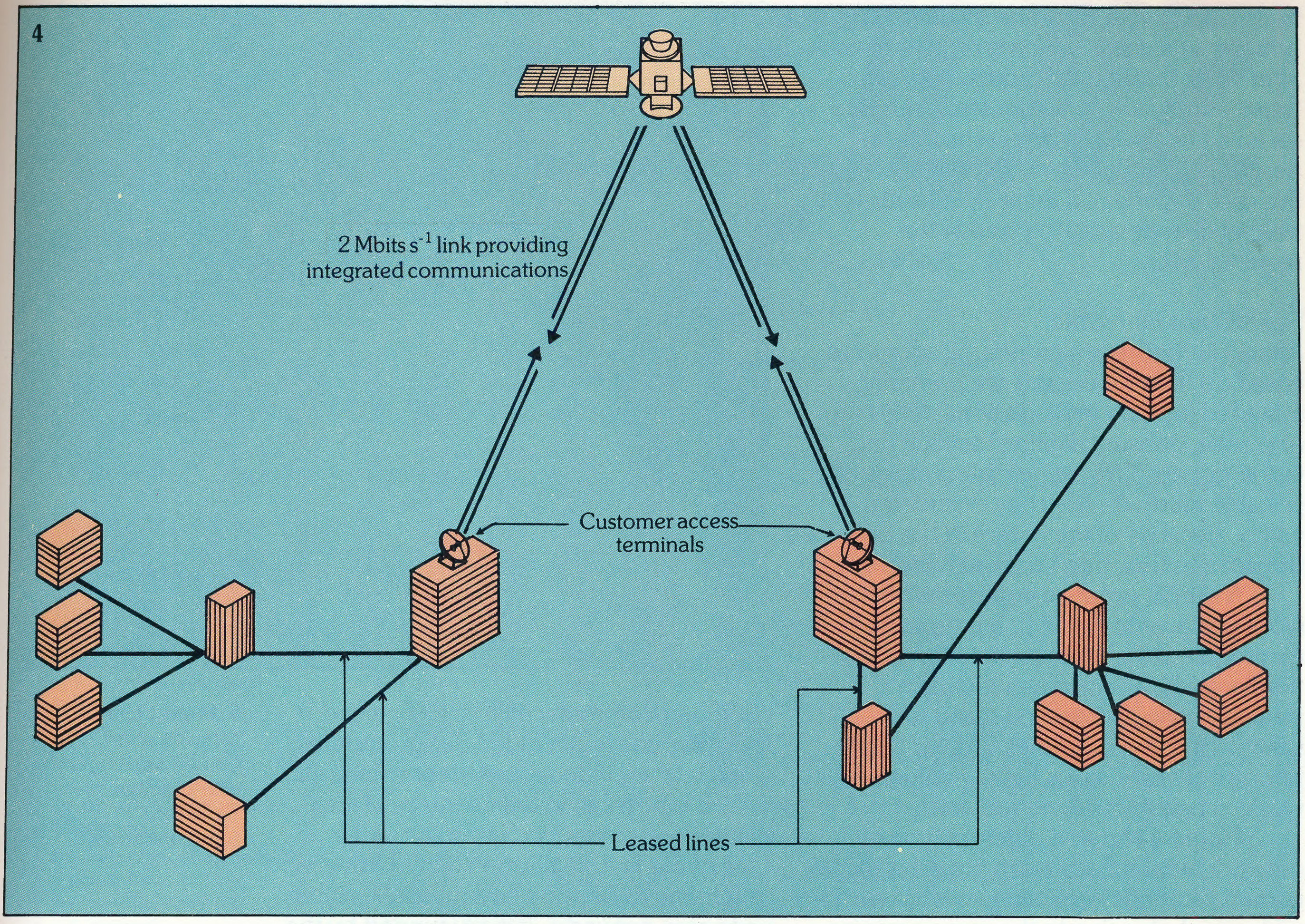
3) **SatStream Offshore** (*figure 2c*). This service is planned to begin operations in 1986, linking offshore oil and gas drilling rigs and platforms with a community earth station located in Aberdeen. The Aberdeen community terminal will, in fact, be the operational centre for all U.K. offshore communications activities. From Aberdeen, all communications will be relayed to and from respective customer sites by conventional land, radio or even further satellite links.

SatStream facilities

Communication links within SatStream Europe and SatStream Offshore are based on digital communications at a data signalling rate of 64,000 bits s^{-1} – this will enable them to be easily linked to the integrated services digital telephone network, as it becomes available. Customers can use more than one link in parallel so that data signalling rates of any multiple of 64,000, up to 2 Mbits s^{-1}, can be obtained.

Links to North America are tailored to suit the North American telephone system, at data signalling rates of 56,000 bits s^{-1} multiples, up to 1.544 Mbits s^{-1}.

Customer communications can be provided on a full-time, part-time or temporary basis. Regular part-time links give the user a satellite communications facility between sites at the same time, for a set period, each day. Alternatively, the cus-



4. A SatStream communications link between two different sites.

Right: SatStream receiving dish mounted on a City roof-top. (Photo: British Telecom).

tomer may prefer to define a pattern of hours over a week, which is repeated week after week through the contract period. Services may also be requested and used on an ad hoc basis, to meet short-term needs. The availability of the services in this case depends on there being sufficient free satellite capacity to provide the required links.

SatStream networks

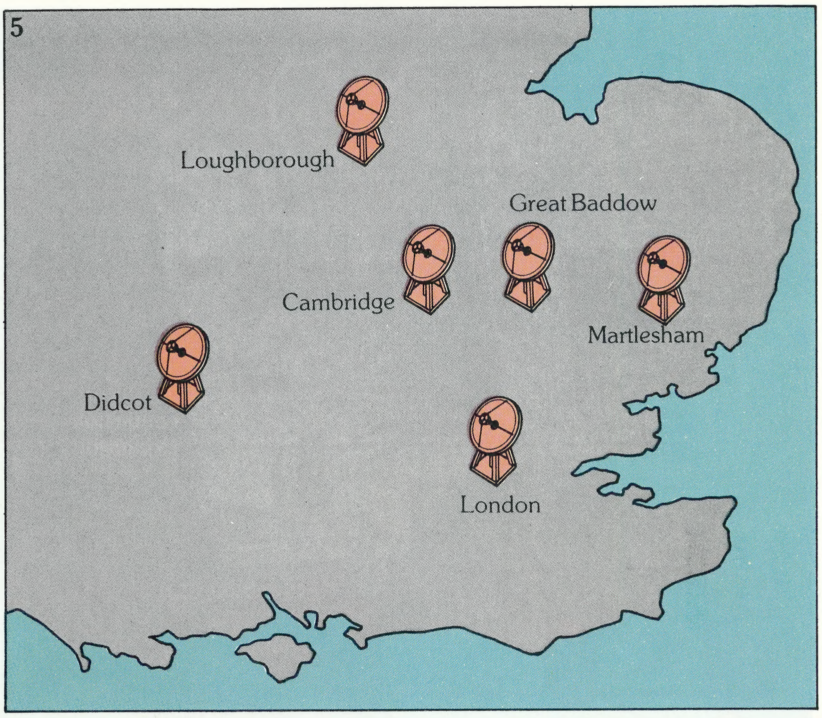
Although SatStream communications are based on digital links and are primarily intended for data transmissions, they can, of course, transmit digitised speech and vision signals. This means that a range of possible networks may be constructed which, because of the nature of the SatStream services, need not be permanent.

A simple **point-to-multipoint** network is shown in *figure 3*. It is typical of that required by large, multinational organisations with a central headquarters located in one country and many subsidiaries in other countries. Access to telephone networks or packet switching networks is possible, where required.

Figure 4 shows a different type of network, where SatStream provides digital communications between two large worldwide sites belonging to the same organisation. The 2 Mbits s^{-1} digital link allows up to 30 channels of voice, video or data communications between sites. Data communications may comprise computer-to-computer communications, high speed facsimile, computer aided design systems, telex, teletex, videotex, electronic mail etc.

It is possible to link many local area networks together via SatStream links. One of the first stages in **Project Universe** (a scheme to develop commercially viable wide area networks, initially funded by the Department of Trade and Industry), for example, interconnects seven Cambridge ring local area networks with 2 Mbits s^{-1} SatStream communications (*figure* 5).

5



5. Project Universe connects seven Cambridge Ring LANs with 2 Mbits s^{-1} SatStream communications.

Left: video teleconferencing links business via an audio/video link – saving on expensive airfares.

The Research House/British Telecom

FOLD 2

TEST YOUR PROGRESS with the I.T.E.C. QUIZ

MICROPROCESSORS – 15

1. A transputer can be programmed to operate as a sequential processor.
True or False?

2. What enables the transputer to overcome synchronising problems, when concurrently processing with other transputers?

- **a** High speed parallel links
- **b** High speed serial links
- **c** OCCAM
- **d** Conditional interrupts
- **e** Active processes
- **f** All of these
- **g** None of these

3. There are only three primitive processes in OCCAM.
True or False?

4. How many types of compound processes may be made from OCCAM's primitive processes?

- **a** As many as you need
- **b** Three
- **c** Four
- **d** Eight
- **e** This is a trick question – compound processes cannot be made from primitive processes
- **f** None of these

FOLD 3

5. An OCCAM process may be given a name and is thus similar to:

- **a** Other computing languages' procedures
- **b** A parallel construct
- **c** A channel
- **d** a, c and d
- **e** This is a trick question – processes cannot be named in OCCAM
- **f** None of these

Answers to last week's quiz

COMMUNICATIONS – 20

1 e	4 a
2 a	5 False
3 c	6 b

COMMUNICATIONS – 21

1 e	5 b
2 a	6 a
3 False	7 d
4 c	8 f

COMMUNICATIONS – 22

FOLD 2

1. Cable television companies in Britain are subject to the 'must carry' rule. This means:

- **a** They must offer a wide range of programming
- **b** They must carry a news service
- **c** They must carry the normal broadcast channels
- **d** They must carry a movie channel

2. The original cable networks were used to distribute radio programs.
True or False?

3. The cable distribution method most favoured by the U.K. government is tree and branch.
True or False?

4. The C-MAC system transmits the chrominance and luminance signals separately.
True or False?

FOLD 3

5. The most effective pay-TV security systems scramble the signals in such a way that paid-up subscribers can only receive a descrambled picture when their decoders are addressed by the main control computer.
True or False?

Answers to this week's quiz

MICROPROCESSORS – 15

1 True	
2 b	
3 True	
4 b	
5 a	

COMMUNICATIONS – 22

1 c	
2 True	
3 False	
4 True	
5 True	

FOLD 4

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FOLD 1

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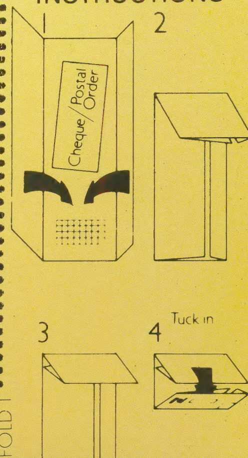

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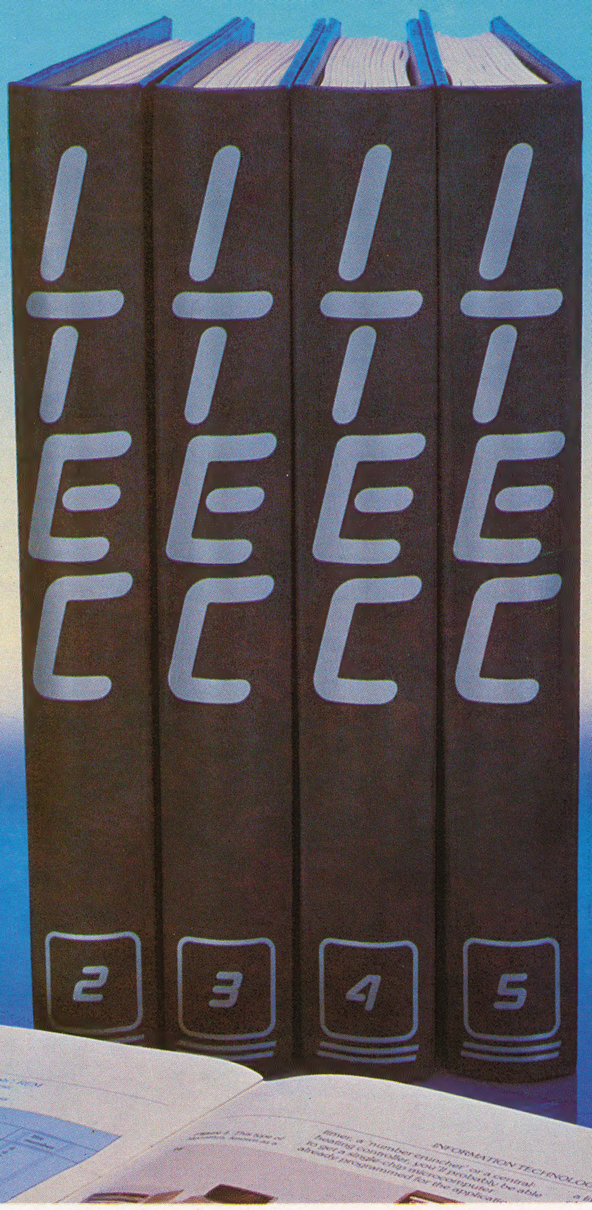

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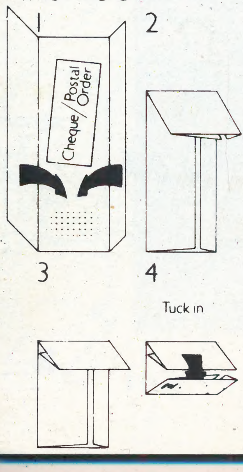

Fold 1

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Fold 1

FOLD 4

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